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Université d'avant-garde

Centre - Eau Terre Environnement
Annual Report 2010-2011



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Director's message

2010-2011

I am pleased to present the 10th annual report of the Centre Eau Terre Environnement of the Institut national de la recherche scientifique for the year 2010-2011.

In conformity with the practice of the Université du Québec Network and at the request of the Quebec government, INRS has adopted a new calendar for the financial year which shortens 2010-2011 by one month. The financial year previously ended on May 31st; it now finishes on April 30th.

The mission of the Centre is to contribute to sustainable development and environmental protection, particularly in the fields of water and earth sciences. Graduate training, diffusion of knowledge, and technology transfer are all essential elements of this mission, and these activities have led to numerous achievements during the year.

This report features the main research projects of the year in the different specialty fields of the Centre. Examples include projects on adapting municipal water infrastructure to climate change and to degradation of water lines, predicting hydrological extremes, determining the impacts of contamination on aquatic organisms, characterizing groundwater in the Monterégie region, reconstructing past environments using lake sediments, studying geological environments for their potential in oil, gas, and minerals, evaluating carbon dioxide geological storage possibilities, and converting municipal and industrial waste into value-added products; all of these projects originated in ideas and initiatives of the Centre's dynamic group of researchers.

Professors at the Centre have had notable successes this year in financing research infrastructure, and two new laboratories were set up, one in environmental hydraulics and the other in bioprocesses and nano-enzyme formulations.



At the INRS fall convocation ceremony, 14 PhD students and 20 Master's students in water and earth sciences received a diploma. In addition, five students completed the professional Master's program in water sciences.

This report highlights the main achievements of the Centre Eau Terre Environnement during 2010-2011. The quality of these achievements and the Centre's overall performance are the result of the vision and actions of knowledgeable, experienced, and committed people. Hence, credit for these successes belongs to the entire community, including professors, students, fellows, research personnel, associate researchers, in particular those of the Geological Survey of Canada with whom we share our offices, and all of the support staff.

I sincerely thank them all and encourage them to pursue their excellent work in the future.

The Director,
Yves Bégin

Centre - Eau Terre Environnement

Institut national de la recherche scientifique

The mission of the INRS (Quebec's national institute of scientific research) is to conduct pure and applied research for the social, economic, and cultural benefit of Quebec. This university research institution seeks to train highly qualified professionals at the graduate level and ensure the transfer of knowledge and technologies in its areas of expertise. The INRS offers to its students and professors an innovative research environment focused on society's needs.

The INRS is composed of four research centres:

- Eau Terre Environnement
(research centre on water, earth, and the environment)
- Énergie Matériaux Télécommunications
(research centre on energy, materials, and telecommunications)
- INRS-Institut Armand-Frappier (health research centre)
- Urbanisation Culture Société
(research centre on urbanization, culture, and society)

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Centre Eau Terre Environnement

The Centre is actively engaged in the sustainable development of Quebec, particularly in the fields of water science, georesources, and the environment. Its research is at the forefront of scientific and technological advances, facilitating the protection and sustainable development of natural resources. The Centre offers graduate programs (PhD, research and professional Master's) in water and earth sciences. Internships are also available at all university levels.

The scientific program is divided into four main research fields: hydrology, biogeochemistry and contamination issues, geological sciences, and environmental decontamination and waste reclamation.

The Centre is located in downtown Quebec City within the urban campus of the Université du Québec. Its large-scale laboratories are located at the Metropolitan Quebec Technology Park, and it has an environmental research station at Sacré-Coeur, in the Saguenay region.



Centre - Eau Terre Environnement

Canada possesses about 9% of the world's fresh water resources

Sustainable management of this vital resource is a priority research subject at the Centre Eau Terre Environnement, which hosts the most important group of university experts in water research in Canada.

The Centre's expertise derives from its long experience in developing and applying numerical approaches to analysis and decision-making in a range of water management contexts. The group's multidisciplinary nature allows thorough analysis of both resource availability and associated environmental problems. A central theme of the Centre's hydrology research is the impact of and adaptation to climate change.

Examples of research applied to current challenges

Monitoring river bank protection from space

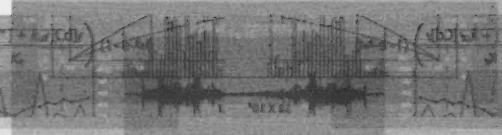
In Quebec, watershed organizations are responsible for implementing integrated management of water resources. One of their concerns is the degradation of riparian buffer strips, which are essential to the protection of lakes and rivers. Researchers are developing a new method to characterize riparian vegetation using high-resolution satellite images. This large-scale analytical tool will help watershed managers assess the state of the buffer strips in order to evaluate their effectiveness.

Hydroelectricity and sustainable development

Canada is a major producer of hydropower, but what are the impacts of this "green" energy on aquatic ecosystems? Canada's Hydronet research network promotes sustainable development of hydroelectricity. In this network, university and Fisheries and Oceans Canada researchers collaborate with hydropower producers to find practical solutions to minimize and mitigate the impacts of hydropower on fish habitats.

Is swimming in the St. Lawrence in Québec City an impossible dream?

In the last few years, Québec City has built several storage reservoirs to reduce wastewater discharge to rivers during periods of heavy rainfall. But are these reservoirs sufficient to ensure a level of water quality adequate for recreational activities on the St-Charles River and beaches of the St. Lawrence? This project consists of a statistical analysis of the relationship between wastewater overflows and river water quality. The other possible sources of water pollution are also examined.



Main study themes and researchers involved



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Examples of recent publications

(INRS-ETE authors are in **bold**)

- Barros, M.D.C., M.J.D. Sena, A.L.A. Mesquita, C.J.C. Blanco & **Yves Secretan** (2011). A water flow pattern analysis of Guajará Bay - Amazon Estuary - Brazil. *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, 33(1): 79-85.
DOI: 10.1590/S1678-58782011000100012
- **Chebana, Fateh & Taha B.M.J. Ouarda** (2011). Multivariate extreme value identification using depth functions. *Environmetrics*, 22(3): 441-455.
DOI: 10.1002/env.1089
- **Chokmani, Karem, Kristell Dever, Monique Bernier, Yves Gauthier & Lisa-Marie Pâquet** (2010). Adaptation of the SNOWMAP algorithm for snow mapping over eastern Canada using Landsat-TM imagery. *Hydrological Sciences Journal*, 55 (4): 649-660.
DOI: 10.1080/02626661003747374
- **Duchesne, Sophie, Nabila Bouzida & Jean-Pierre Villeneuve** (2010). Performance estimation of a Remote Field Eddy Current method for the inspection of water distribution pipes. *Journal of Water Resources Planning and Management*, Online.
DOI: 10.1061/(ASCE)WR.1943-5452.0000136
- **Grenier, Martine, Isabelle Lavoie, Alain N. Rousseau & S. Campeau** (2010). Defining ecological thresholds to determine class boundaries in a bioassessment tool: The case of the Eastern Canadian Diatom Index (IDEC). *Ecological Indicators*, 10(5): 980-909.
DOI: 10.1016/j.ecolind.2010.03.003
- **Guillemette, Nicolas, André St-Hilaire, Taha B.M.J. Ouarda & Normand Bergeron** (2010). Statistical tools for thermal regime characterization at segment river scale: Case study of the Ste-Marguerite River. *River Research and Applications*, 27(8): 1058-1071.
DOI: 10.1002/rra.1411
- **Mailhot, Alain, Ahmadi Kingumbi, Guillaume Talbot & Audrey Poulin** (2010). Future changes in intensity and seasonal pattern of occurrence of daily and multi-day annual maximum precipitation over Canada. *Journal of Hydrology*, 388: 173-185.
DOI: 10.1016/j.jhydrol.2010.04.038

Some research partners

- Canadian and European Space Agencies
- Government of Canada (Agriculture and Agri-Food; Environment; Fisheries and Oceans)
- Government of Quebec (Agriculture, Fisheries and Food; International Relations; Sustainable Development, Environment and Parks; Transport)
- Hydro-Québec
- Institut de recherche et de développement en agroenvironnement (IRDA)
- Ouranos Consortium on Regional Climatology and Adaptation to Climate Change
- Québec City

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Centre - Eau Terre Environnement

Water pollution is one of the main environmental problems confronting society

Pollutants enter aquatic ecosystems from point (e.g. spills) and diffuse (e.g. pesticides) sources, accumulate in sediments, and concentrate up the food chain. A good knowledge of the processes controlling the exchange of toxic substances between sediments, the water column, and aquatic organisms, and of the effects of these substances on ecosystems, is essential in order to remediate the problem.

The Centre Eau Terre Environnement biogeochemistry research group makes a unique contribution to remediation efforts through its capacity to combine research on contaminant dispersion in the environment, the assimilation of and effects of trace metals on aquatic organisms, and the detection of environmental changes in aquatic ecosystems by using certain organisms as sentinels.

Examples of research applied to current challenges

Nanotech with macro effects?

Silver nanoparticles are increasingly used in a wide variety of consumer products, particularly for their antibacterial properties. These infinitesimal particles (nanoscale corresponds to one billionth of a metre) ultimately end up in wastewater discharged to rivers. The concentration of these particles in the environment and their effects on aquatic organisms are unknown. This research project is designed to evaluate the ecological risk to aquatic environments posed by nanosilver.



The great migration of eels

Both the American and the European eel populations are declining. For centuries, their life cycle had an aura of mystery around it, but we know today that they are born and reproduce in the Sargasso Sea, in the south-western part of the North Atlantic Ocean, but go back to rivers in between. During their slow growth in freshwater, the eels accumulate great quantities of contaminants. This project, a Quebec-France collaboration, examines the impacts of this contamination on the health and reproduction of these unique fish.



Salmonids in hot water?

The increase in temperature related to global warming will be felt not only in the air but also in water. Salmonids are sensitive to temperature increase since they prefer cool well-oxygenated water. The objective of this Ouranos Consortium project is to map the evolution of salmonid habitats according to various scenarios of global warming for the three main climatic zones of Quebec. This will help identify risk zones and plan long-term management of these species, which are very important for sport fishing.



Main study themes and researchers involved



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Examples of recent publications

(INRS-ETE authors are in bold)

- Boulemant, A., **Séverine Le Faucheur**, **Claude Fortin** & **Peter G.C. Campbell** (2011). Uptake of lipophilic cadmium complexes by three green algae: influence of humic acids and its pH-dependence. *Journal of Phycology*, 47(4): 784-791.
DOI: 10.1111/j.1529-8817.2011.01013.x
- **Cooper, Sophie**, **Landis Hare** & **Peter G.C. Campbell** (2010). Subcellular partitioning of cadmium in the freshwater bivalve, *Pyganodon grandis*, after separate short-term exposures to waterborne or diet-borne metal. *Aquatic Toxicology*, 100(4): 303-312.
DOI: 10.1016/j.aquatox.2010.07.027
- **Drevnick, Paul**, D. Muir, C. Lamborg, M. Horgan, D. Canfield, J. Boyle & N. Rose (2010). Increased accumulation of sulfur in lake sediments of the High Arctic. *Environmental Science & Technology*, 44(22): 8415-8421.
DOI: 10.1021/es101991p
- **Feyte, Stéphane**, **André Tessier**, **Charles Gobeil** & D. Cossa (2010). *In situ* adsorption of mercury, methylmercury and other elements by iron oxyhydroxides and organic matter in lake sediments. *Applied Geochemistry*, 25(7): 984-995.
DOI: 10.1016/j.apgeochem.2010.04.005
- Martin, J., J.E. Tremblay, J. Gagnon, G. Tremblay, A. Lapoussière, C. Jose, M. Poulin, M. Gosselin, **Yves Gratton** & C. Michel (2010). Prevalence, structure and properties of subsurface chlorophyll maxima in Canadian Arctic waters. *Marine Ecology Progress Series*, 412: 69-84.
DOI: 10.3354/meps08666
- Morbey Y.E., **Patrice Couture**, P. Busby P. & B.J. Shuter (2010). Physiological correlates of seasonal growth patterns in lake trout *Salvelinus namaycush*. *Journal of Fish Biology*, 77(10): 2298-2314.
DOI: 10.1111/j.1095-8649.2010.02804.x
- Watanabe S., **Isabelle Laurion**, R. Pienitz, **Karem Chokmani** & W.F. Vincent (2011). Optical diversity of thaw ponds in discontinuous permafrost: A model system for water color analysis. *Journal of Geophysical Research - Biogeosciences*, 116: G02003.
DOI: 10.1029/2010JG001380

Some research partners

- ArcticNet Network
- Natural Resources Canada
- Ontario Ministry of the Environment
- Ouranos Consortium on Regional Climatology and Adaptation to Climate Change
- Quebec Ministry of Natural Resources and Wildlife
- Rio Tinto Alcan
- Vale Inco

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Centre - Eau Terre Environnement

Geoscience research addresses several of the main socio-economic issues that society currently faces

The increasing demand for natural resources, the need for sustainable management of ground-water resources, the risks posed by natural hazards related to geological processes, and the impacts of climate change are all crucial issues for researchers in geological sciences.

The Centre Eau Terre Environnement and the Quebec division of the Geological Survey of Canada are partners within a scientific collaboration agreement between the INRS and Natural Resources Canada. This university-government partnership has created the most important multidisciplinary research group in geosciences in Canada, the Centre géoscientifique de Québec (CGQ).

Examples of research applied to current challenges

Drinking water: a subsurface alternative

For more than one third of Quebec's municipalities, drinking water comes from surface water, despite the problems associated with ice in winter and with water quantity and quality in summer. Water intakes located underwater and in river banks benefit from filtration by sediments. They could constitute an interesting solution to these problems. A hydrogeological study is underway to establish criteria for the design, operation, and maintenance of this type of water intake. A guide for municipalities integrating these criteria is in preparation.

Soil stability in the northern channel of Île d'Orléans

The Île d'Orléans bridge near Québec City was built in 1935 and must now be replaced. Soil stability below the St. Lawrence River will be a decisive factor in choosing the site where the new bridge will be built. In addition, Hydro-Québec plans to install a power line under the St. Lawrence. To help decide where these infrastructure items should be located, seismic measurements were taken in the northern channel of the island to determine the nature and position of the different soil layers from the surface down to the bedrock.

An ore deposit worth its weight in gold

Since several gold mines are already in operation in the Abitibi-Témiscamingue region of Quebec, one might believe that the potential for new mines is exhausted, but a recent discovery has shown that this is not the case. The Westwood deposit, near Rouyn-Noranda, contains world-class gold resources. It also contains other precious (silver) and common (zinc, copper) metals. Researchers are analyzing the geochemistry of the mineralized zones of this deposit and studying its geometry using structural analysis. The knowledge obtained will contribute to the search for other deposits of this type in the area.



Main study themes and researchers involved



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Examples of recent publications

(INRS-ETE authors are in bold)

- **Cuven, Stéphanie, Pierre Francus** & S. Lamoureux (2010). Estimation of grain size variability with micro X-ray fluorescence in laminated lacustrine sediments, Cape Bounty, Canadian High Arctic. *Journal of Paleolimnology*, 44(3): 803-817.
DOI: 10.1007/s10933-010-9453-1
- **Giroux, Bernard** & M. Chouteau (2010). Quantitative analysis of water content estimation errors using Ground Penetrating Radar data and a low-loss approximation. *Geophysics*, 75(4): WA241-WA249.
DOI: 10.1190/1.3464329
- Godin, L., C. Yakymchuk & **Lyal B. Harris** (2011). Himalayan hinterland-verging superstructure folds related to foreland-directed infrastructure ductile flow: Insights from centrifuge analogue modelling. *Journal of Structural Geology*, 33(3): 329-342.
DOI: 10.1016/j.jsg.2010.09.005
- **Laporte-Saumure, Mathieu, Richard Martel** & **Guy Mercier** (2010). Evaluation of physicochemical methods for treatment of Cu, Pb, Sb, and Zn in Canadian small arm firing ranges backstop soils. *Water Air & Soil Pollution*, 213(1-4): 171-189.
DOI: 10.1007/s11270-010-0376-2
- **Paradis, Daniel, René Lefebvre, R.H. Morin** & **Erwan Gloaguen** (2011). Permeability profiles in granular aquifers using flowmeters in direct-push wells. *Ground Water*, 49(4): 534-547.
DOI: 10.1111/j.1745-6584.2010.00761.x
- **Ross, Pierre-Simon, Séverine Delpit, M.J. Haller, K. Némethi** & H. Corbella (2011). Influence of the substrate on maar-diatreme volcanoes – an example of a mixed setting from the Pali Aike volcanic field, Argentina. *Journal of Volcanology and Geothermal Research*, 201(1-4): 253-271.
DOI: 10.1016/j.jvolgeores.2010.07.018
- **Sulis, Mauro, Claudio Paniconi, C. Rivard, R. Harvey** & D. Chaumont (2011). Assessment of climate change impacts at the catchment scale with a detailed hydrological model of surface-subsurface interactions and comparison with a land surface model. *Water Resources Research*, 47: W01513.
DOI: 10.1029/2010WR009167
- **Xhardé, Régis, Bernard F. Long** & D.L. Forbes (2011). Short-term beach and shoreface evolution on a cusate foreland with airborne topographic and bathymetric Lidar. *Journal of Coastal Research, Special Issue* (62): 50-61.
DOI: 10.2112/SI_62_6

Some research partners

- Dessau and Roche
- DIVEX (DIVersification de l'EXploration minérale au Québec) Network
- Government of Canada (Justice; National Defence; Natural Resources)
- Government of Quebec (Municipal Affairs and Regions; Natural Resources and Wildlife; Sustainable Development, Environment and Parks)
- IAMGOLD
- J.A.G. Mines
- Ouranos Consortium on Regional Climatology and Adaptation to Climate Change

Centre - Eau Terre Environnement

Waste needs to be managed as a resource if the sustainable use of natural resources is to be attained

Cities and industries face major challenges with respect to waste recycling and reuse, and thus methods and technologies have to be adapted continuously.

The Centre Eau Terre Environnement is a leader in the development of environmental technologies. Its researchers possess unique expertise in the development of treatment and reclamation technologies of contaminated sewage sludge, effluents, and solid waste. Moreover, the Centre has one of the most complete and flexible pools of pilot equipment and analytical instruments in Canada for research and development projects. New technologies conceived at the Centre are regularly patented and transferred to industry.

Examples of research applied to current challenges

Asbestos and CO₂: a promising match

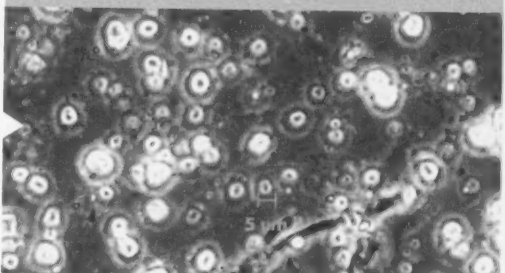
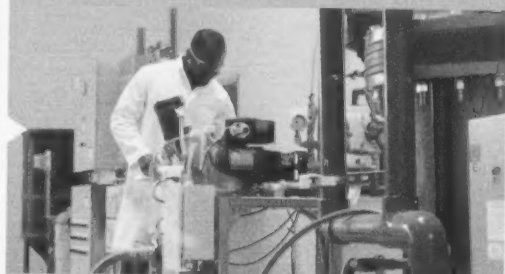
One way of reducing greenhouse gas emissions is to collect CO₂ directly from industrial emissions. This innovative project seeks to combine basic mining residues, such as those of the asbestos industry, which Quebec has in great quantity, with CO₂ to form carbonates. This process has the potential both to convert asbestos fibres into a safe product and to produce metal concentrates that eventually could be marketed.

Caution, hazardous wastes!

The term "hazardous wastes" says it all: such materials should not be released into the environment. However, leachate from leaking landfill sites contaminates groundwater with ion fluorides, chlorides, and ammoniacal nitrogen. To remediate the problem, three treatment combinations are being tested in the laboratory to assess their performance in reducing the concentrations of these pollutants to acceptable levels. The most effective treatment will be further examined for an *in situ* application.

No compromise on taste

Quebec's microbreweries produce specialty beers sought after by connoisseurs. But making a good beer is not an easy task! Beer production requires several steps, of which the solid-liquid separation stage is crucial, since the taste and aroma of the end product must not be compromised. This research project is testing the use of new biodegradable flocculating agents to optimize the separation process. All phases are included in the project, from laboratory testing to commercial application.



Main study themes and researchers involved



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Rajeshwar Dayal Tyagi | Bioconversion
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Examples of recent publications

(INRS-ETE authors are in **bold**)

- **Adjallé, Kokou D., Dang Khanh Vu, Rajeshwar Dayal Tyagi, Satinder Kaur Brar, J.R. Valéro & R.Y. Surampalli** (2011). Optimization of spray drying process for *Bacillus thuringiensis* fermented waste water and wastewater sludge. *Bioprocess and Biosystems Engineering*, 34(2): 237-246.
DOI: 10.1007/s00449-010-0466-y
- Janin, A., **Lucie Coudert, Pauline Riche, Guy Mercier, P. Cooper & Jean-François Blais** (2011). Application of a CCA-treated wood waste decontamination process to other copper-based preservative-treated wood after disposal. *Journal of Hazardous Materials*, 186(2): 1880-1887.
DOI: 10.1016/j.jhazmat.2010.12.094
- **Mohapatra, Dipti Prakash, Fatma Gassara & Satinder Kaur Brar** (2011). Nanoparticles - production and role in biotransformation. *Journal of Nanoscience and Nanotechnology*, 11(2): 899-918.
DOI: 10.1166/jnn.2011.3844
- **Tran, Lan-Huong, Patrick Drogui, Guy Mercier & Jean-François Blais** (2010). Comparison between Fenton oxidation process and electrochemical oxidation for PAH removal from an amphoteric surfactant solution. *Journal of Applied Electrochemistry*, 40(8): 1493-1510.
DOI: 10.1007/s10800-010-0128-4
- **Zidane, F., K. Cheggari, Jean-François Blais, Patrick Drogui, J. Bensaid J. & S. Ibn Ahmed** (2010). Contribution à l'étude de l'effet de la coagulation avant chloration sur la formation des trihalométhanes (THM) et composés organohalogénés (COX) dans les eaux alimentant la ville de Casablanca au Maroc. *Canadian Journal of Civil Engineering*, 37(8): 1149-1156.
DOI: 10.1139/L10-065

Example of patent

- **Bergeron, Mario & Alain Langlais** (2011) & (2009). GeCl_4 and/or SiCl_4 recovery process from optical fibers or glassy residues and process for producing SiCl_4 from SiO_2 rich materials.
[Patent Republic of South Africa: 2010/04663] & [PCT International Patent: CA 2008-002106]

Some research partners

- Filter Innovations
- Government of Quebec (Agriculture, Fisheries and Food; International Relations; Sustainable Development, Environment and Parks)
- La Barberie
- Premier Tech
- Société de protection des forêts contre les insectes et maladies (SOPFIM)
- Tecosol

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Centre - Eau Terre Environnement

Hydrology

Watershed hydrology

Monique Bernier continued her work within ArcticNet (www.arcticnet.ulaval.ca) during the year (the network's funding was renewed in 2011). Her team is focused on developing algorithms to map snow cover and thickness and relate these variables to the thermal regime of permafrost soils. She completed her contribution to an International Polar Year project aimed at adapting to the tundra the algorithms used to map and monitor frozen soils using combined SSM/I and RADARSAT data. Her team also collaborated with researchers from Agriculture and Agri-Food Canada on two contracts: one on the dynamics of frozen soil in relation to its pedological properties (granulometry, organic matter content, drainage) and the other on the identification of crop residues using SPOT-4 satellite optical images.

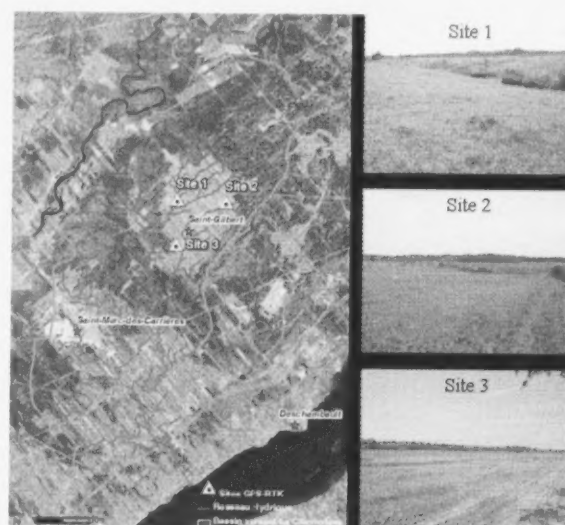
North Hydrology is a collaborative project involving five northern countries led by the University of Waterloo and funded by the European Space Agency. In this project, **Monique Bernier's** team pursues the development of remote sensing monitoring tools for river ice dynamics, including the IceMap algorithm and GIS tools from the FRAZIL project. These tools will be integrated into flood prediction systems.

Dr. Bernier's team continued to work on a project of the Ouranos Consortium (www.ouranos.ca) on the behaviour of shore ice near six communities in Nunavik. The objective is to obtain both an historical characterization of the ice using observations from residents and camera monitoring and a spatial characterization using satellite imagery. In addition, her team collaborates on the development of practical scientific activities adapted for high school students in Nunavik. The objectives are to give tools to the teachers to help their students learn more about climate change and to promote school engagement in environmental monitoring. In particular, students are introduced to remote sensing and its multiple uses using ice monitoring activities.

Within the WESNET Strategic Network (www.wesnet.ca), Dr. Bernier and her team work on new approaches to evaluate and map wind resources in coastal regions using RADARSAT-1 and 2 images. The Îles-de-la-Madeleine region has excellent potential for wind energy projects and will thus be used to validate the work.

Karem Chokmani is particularly interested in the development of stochastic approaches to spatiotemporal monitoring of snow cover using remote sensing data. He collaborates with the research institute of Hydro-Quebec on mapping snow cover extent in near real time. The project includes development of an algorithm using images from the NOAA-AVHRR optical sensor, comparison of available algorithms for different sensors, and development of an approach based on the results from a group of algorithms.

Dr. Chokmani's team has begun a project to develop a characterization method for riparian vegetation strips using very-high-resolution satellite imagery and object-based classification. This methodology will be useful to managers who want to evaluate the state and effectiveness of buffer strips within a watershed.



The three sites used to test the buffer strip characterization method in the Chevrolière River watershed, Quebec

In collaboration with researchers from Morocco and Tunisia, two countries where soil salinification is a major concern, **Karem Chokmani** is working on a method to map and monitor soil salinity using radar remote sensing. The objective is to evaluate the potential of Synthetic Aperture Radar (SAR) data in two sites, one in the centre of Morocco and the other in central Tunisia, using the object-based classification approach.

Alain N. Rousseau's research program focuses on improving distributed hydrological models and their applications within the context of integrated watershed management. With his team, he continues the adaptation of the HYDROTEL model to the boreal zone that was initiated in a previous project in partnership with the Ouranos Consortium and Hydro-Quebec. The current phase includes three main activities: 1) modeling of hydrological processes, 2) model calibration and analyses of sensitivity, identifiability, and uncertainties, and 3) improvements to HYDROTEL and PHYSITEL software. In another Ouranos project, his team is collaborating with the Centre d'expertise hydrique du Québec to integrate climate change impacts in the estimation of probable maximum floods, a variable used in the evaluation of dam safety. **André St-Hilaire** is collaborating on the first project, and **Alain Mailhot** on both projects.

Alain N. Rousseau's team is involved in two other Ouranos projects related to climate change. The first is an evaluation of the impacts of agroforestry systems on hydrological processes and soil erosion. In the second project, tools are developed to analyse the hydrological, economic, and spatial aspects of the ecological services provided by wetlands in the St. Lawrence lowlands.

Dr. Rousseau is carrying out two projects for Agriculture and Agri-Food Canada. The first involves writing a report on the method of calculation of the Topographic Index (an index based on digital elevation and geospatial data) and results obtained for all agriculturally classified watersheds in Canada. In the second project, he models the effects of certain agricultural best management practices (such as buffer strips and underground drainage) on watershed water quality. **Claudio Paniconi** and **Pierre Lafrance** contribute to the latter project.

The AQUALYSE 2 project of the Ouranos Consortium was completed this year. Hydrology and greenhouse gas flux assessments were made for an aqualized peatland in the James Bay region. **Monique Bernier**, **Karem Chokmani**, **Alain N. Rousseau**, and **André St-Hilaire's** teams were involved in this project led at Laval University.

Jean-Pierre Villeneuve's research interests relate to mathematical modeling applied to integrated watershed management, including the use of the GIBSI software. He continues to collaborate with researchers from Vietnam with the objective of implementing this approach to water management in that country.

Urban hydrology

Sophie Duchesne's research program focuses on mathematical modeling applied to the management of water-related infrastructure (water supply and sewage networks) and of water resources in urban areas. Her team develops models to predict the evolution of the degradation of water and sewer lines. This work is done in collaboration with **Jean-Pierre Villeneuve**.

Québec City mandated **Sophie Duchesne** to identify the sources of the pollution affecting water quality in the St-Charles River and

the St. Lawrence near the city's beaches and to suggest possible actions. The contract included quantification of the relationship between the city's sewage system overflows and river water quality.

Alain Mailhot's team is involved in a project of the Ouranos Consortium on the impact of climate change on the management of rainwater in urban areas. The objective is to evaluate rainwater infrastructure performance and to examine different adaptation strategies. In another project, his team analyzes precipitation extremes simulated by the Canadian Regional Climate Model for southern Quebec. Local and regional frequency analysis is applied to both the current climate and the predicted future climate. **Sophie Duchesne** is collaborating on the first project.

Alain Mailhot and his team are contributing to the production of an Agroclimatic Atlas for Quebec by analyzing the trends of several agroclimatic indices based on daily temperature and precipitation data compiled by Quebec and Canada's environment ministries. They are also taking part in the development of a hydrological prediction tool to be used in the design of hydro-agricultural infrastructure. The tool will take into account the recent evolution in the intensity, duration, and frequency of precipitation and winter mild spells associated with climate change.

Environmental hydraulics

Norman Bergeron's research interests relate to the geomorphology of the winter habitat of salmonids. His team continued its work on the use of passive integrated transponder technology to model the capacity of brook trout to pass through different types of road culverts. He started a new project to study the impacts of forest road culverts on brook trout populations in the boreal forest of Saguenay-Lac-Saint-Jean. At the scale of an individual culvert, the focus is on fish passage success, and at the subwatershed scale, the cumulative effects of active and abandoned culverts on river habitat fragmentation are evaluated. **Patrice Couture** and **Taha B.M.J. Ouarda** are contributing to the second project.

Norman Bergeron is collaborating with **Patrice Couture** to study the seaweed *Didymosphenia geminata* (dydimo), which recently invaded rivers in Quebec and New Brunswick. This alga can form mucilaginous mats that modify fish habitat characteristics. This project seeks to evaluate the short- and medium-term impacts of dydimo on the production of juvenile Atlantic salmon in the Restigouche River watershed. Finally, the Ouranos Consortium project on the development of hydrosedimentary modeling tools for St. Lawrence tributaries, on which **Yves Secretan** was collaborating, is now finished.

The mission of the new Canadian network Hydronet (www.hydronet.umontreal.ca) is to promote sustainable hydropower via a better understanding of the effects of hydroelectric operations on aquatic ecosystems. In this network, **Normand Bergeron** has a project on the physical characterization of lake and reservoir habitats using aerial photography and hydroacoustic techniques.

Yves Secretan continues to offer support and training for the use of Modeleur/Hydrosim/H2D2 software. His team also works to improve the performance and precision of the numerical hydrodynamic modeling system for the St. Lawrence River (H2D2).

Statistical hydrology

Fateh Chebana's team is involved in an international project in cooperation with the University of Biskra in Algeria. High levels of evaporation and sedimentation of hydraulic structures contribute to a shortage of water in this country. Frequency analysis is used to predict the occurrence and frequency of extreme hydrological events, droughts in particular. The project has a double goal: to improve the management of silting at target sites and to better predict extreme events for the management of water resources. **Taha B.M.J. Ouarda** is collaborating on this project.

In a project in collaboration with the University of Lille 3 (France), **Fateh Chebana** is using the promising new method of Functional Data Analysis to make the most of the information contained in hydrographs (water flow records) and thus provide better predictions of extreme hydrological events.

The research interests of **Taha B.M.J. Ouarda** relate to extreme hydrometeorological events and climate change. He holds the Canada Research Chair in Hydrometeorological Variable Assessment. His team pursued its collaboration with Environment Canada on the use of high-resolution climate scenarios to study the impacts of climate change on hydrological extremes (floods, low water levels). They also joined forces with a Belgian team in order to improve precipitation forecasts using Bayesian data fusion models.

Dr. Ouarda's team continued to build a database and work on a tool to estimate daily river flows for all ungauged Great Lakes basins. This tool is intended for the International Joint Commission, which assists the U.S. and Canadian governments in the management of boundary waters. The Commission also funded work to improve the modeling of the Great Lakes basins' water supply components. In addition, this team carried out a sensitivity study of the model they developed for the Canadian Coast Guard to predict ships' squat in the St. Lawrence waterway. A new model is currently in development.

One of **André St-Hilaire's** research objectives is to develop statistical models to predict the thermal regime and the concentration of suspended solids in rivers. Working with his team, he is seeking to better understand the variability in the sediment supply to Saint John Harbour in New Brunswick by analyzing the Saint John River's sedimentary load in relation to hydrometeorological variables. He has been mandated by Québec City to monitor the temperature of a lake located in an outdoor recreational area to verify if the temperature variations in the lake will be lessened once its banks are restored.

Dr. St-Hilaire is also involved in the Hydronet Network as a leader of the component examining the effects of dams on the thermal

regime of rivers. **André St-Hilaire** and **Normand Bergeron's** teams are collaborating on a project of the Ouranos Consortium to model river thermal refugia for salmon in relation to climate change.

André St-Hilaire is contributing to a research project on the sustainable management of peatland forests. Monitoring of the suspended particles and water flow in a river upstream and downstream from a logged forest plot will enable identification of changes in water quantity and quality. He is responsible for the hydrology aspect of a project on the impact of climate change on river bank erosion in St. Lawrence tributaries. This is done in collaboration with colleagues from the University of Montréal. His team has also been mandated to make a statistical analysis of the water quality measurement network in Saskatchewan rivers and Lake Winnipeg. The latter work has been carried out in collaboration with **Taha B.M.J. Ouarda**.

These two researchers' teams continued to collaborate with Hydro-Quebec to develop statistical tools to assist in the design and operation of hydraulic structures in relation to river flows and climatic variables. Finally, they concluded their participation in an international research initiative to produce probabilistic scenarios of regional change in climatic variability and extremes.

Biogeochemistry and contamination issues

Environmental geochemistry

Charles Gobeil's research interests relate to the ubiquitous contamination of aquatic environments, including identification of reactions involving contaminants in the sediments and *in situ* determination of reaction speeds and constants. He contributed to the development of a model (not subjected to a steady state constraint) of the reactive transport of arsenic in sediments. The scientific approaches advanced by this research are relevant in the context of the planned increased exploitation of the mineral resources of Northern Quebec.

Other work by Dr. Gobeil concerns the cycle of organic carbon and elements sensitive to changes in redox conditions of organic matter, such as manganese and iron, in sediments of the Arctic continental margins of North America. Results from this research have enabled the determination of mass balances of element sources and sinks in the Arctic Ocean and revealed the importance of sea level fluctuations for biogeochemical changes in this ocean.

Pierre Lafrance's research program focuses on the transport and fate of pesticides in agricultural areas and on pesticide attenuation processes, with the objective of reducing water contamination. *In situ* studies on pesticide transfer to surface and groundwater are carried out at the scales of the cultivated plot and subwatershed. The attenuation performance of buffer strips, for example, is evaluated. This work is used in modeling pesticide transport to

streams and rivers (a collaboration with **Alain N. Rousseau**) and in estimating contamination risks.

Agriculture and Agri-Food Canada is carrying out an evaluation of agricultural best management practices (BMPs). **Pierre Lafrance's** contribution concerns the fate of two herbicide compounds in the Bras d'Henri subwatershed (near Québec City). The goal is to evaluate the performance of BMPs (vegetated riparian buffer strips and grassed waterways) in reducing the transfer of pesticides to surface water.

Aquatic ecotoxicology

Peter G.C. Campbell started a new phase in his research program on metal speciation, bioavailability, and toxicity in aquatic environments. The objective is to determine the relationships between metals' states (i.e., speciation) and their biological effects. He is interested in metal speciation not only in aquatic environments, but also at the surface of cells and within the intracellular medium. He holds the Canada Research Chair in Ecotoxicology of Metals. The chair's team tests metal bioaccumulation models for aquatic organisms and develops innovative methods to detect the effects of metals on those organisms and to take into account the organisms' detoxification capacity. Centre researchers contributing to this chair are **Patrice Couture**, **Paul Drevnick**, **Claude Fortin**, and **Landis Hare**.

Patrice Couture's research program focuses on the combined effects of metal contamination and climate change on aquatic organisms. He studies the mechanisms of metal toxicity and tolerance in fish in relation to temperature and hypoxia.

Patrice Couture's research team collaborates with that of **Peter G.C. Campbell** on two projects. The first, a partnership with industry, concerns metal contamination in perch. This project combines field and laboratory experiments to identify the specific signature of metals in perch genes. French researchers are involved in the second project, which seeks to evaluate the impacts of habitat contamination on the health and reproduction of the declining populations of American and European eels. The pollutants bioaccumulated during the slow growth of eels in freshwater can be transferred to gonads and muscles during the eels' migration towards the Sargasso Sea; the effects of these pollutants are examined.

Paul Drevnick's research program relates to the environmental factors affecting mercury methylation in lakes and to the effects of this pollutant on fish. He is conducting research in several Canadian provinces, and his ultimate objective is to make recommendations to fisheries managers. He has begun a project in the Mauricie region, which is a hot spot for mercury contamination in Quebec. He is studying the effects of this metal on the anatomy and physiology of brook trout, a very popular sport fish. The populations at risk will be identified. The goal is to build a demographic model to help understand the ecological effects of mercury on this fish species and eventually on others as well.



One of the numerous lakes of La Mauricie National Park

The main objective of **Claude Fortin's** research is to improve predictive models of the bioavailability of trace elements in aquatic environments in order to contribute to the protection of these ecosystems. He has started to work on two new projects with his team making use of the IDEC (Eastern Canadian Diatom Index). Diatoms are microscopic algae; this index enables the integration of different types of river degradation (mainly eutrophication). In the first project, they seek to optimize the IDEC for Ontario rivers, and in the second, they use this index to evaluate the quality of Gatineau Park rivers and streams and to identify problematic sites.

Dr. Fortin's team is collaborating with Rio Tinto Alcan on its objective of reducing the ecological impacts of its aluminum plants in Saguenay-Lac-Saint-Jean. They are working, in particular, on the impacts related to wastewater discharge containing aluminum and fluoride. Work is underway to better understand the relationships between the distribution of chemical elements in solution and their bioavailability for aquatic organisms, using a unicellular green alga as a model.

Claude Fortin and **Peter G.C. Campbell's** research teams are collaborating on a project led at the University of Montréal on silver nanoparticles (Ag-NP), an increasingly used nanomaterial. They seek to determine the ecological risk posed to aquatic environments by Ag-NP.

Landis Hare's research program focuses on modeling the bioavailability, bioaccumulation, and toxicity of trace metals in aquatic invertebrates in order to predict the contamination state of lakes. He uses invertebrates as sentinel organisms.

Limnology

Cyanobacterial blooms in lakes pose several problems. **Isabelle Laurion's** research team, in collaboration with **Karem Chokmani**, is developing monitoring tools for this increasingly common phenomenon using *in vivo* fluorescence probes and satellite imagery.

Isabelle Laurion's expertise on lake eutrophication and cyanobacterial blooms is regularly solicited. For example, her team conducted a limnological study of Lake St-Charles, Québec City's drinking water supply. She also completed an evaluation of the causes and risk factors of the cyanobacterial blooms that have been observed in some lakes of the Séminaire de Québec lands.

Dr. Laurion's team is particularly interested in the relationships between climate change, lake eutrophication, cyanobacterial bloom, and greenhouse gas (GHG) production. Their objective is to understand the factors controlling the spatiotemporal variation of GHG emissions by aquatic environments in relation to a lake eutrophication state. The factors include the presence of macrophytes or cyanobacterial bloom, thermal structure, depth, presence of microbes producing/consuming methane, and the importance of methane boiling out of lakes.

Thermokarst ponds are expanding in northern regions as permafrost melts. Dr. Laurion's team and collaborators are studying these ponds to estimate their contribution in the transfer of carbon to the atmosphere and to the hydrological network and to assess the evolution of the ponds in relation to climate change. This project was funded in part by CICAT, a program of the International Polar Year. The microbial diversity of these ponds and their role in GHG production are also examined. The latter project is integrated into the ArcticNet Network and the international programs MERGE and ECOSENSOR.

Yves Gratton's team, in collaboration with those of **Isabelle Laurion** and **André St-Hilaire**, are working to produce maps of salmon preferred habitats for the three climatic zones of Quebec by modeling water temperature and oxygen concentration under different scenarios of global warming. These maps will be useful to fisheries managers.

Oceanography

Yves Gratton's research program focuses on the effects of medium-scale physical processes on marine biological production. The renewal of ArcticNet Network funding and the instruments placed in marine observatories throughout the Canadian Arctic have enabled his team to continue to work on high planktonic productivity zones. In this new research phase, they will focus on ecological services provided and sensitivity to climate change.

Dr. Gratton's team is taking part in a group project with colleagues at Laval and McGill universities in the area around the Mackenzie River mouth in the Beaufort Sea. His team is looking at the impacts of warmer Atlantic waters on ice distribution using a circulation model for the Arctic Ocean. Finally, he completed his contribution to the Circumpolar Flaw Lead System Study, an International Polar Year project that examined the climate changes affecting the circumpolar Arctic.

Geosciences

Geophysics

Bernard Giroux is particularly interested in applied geophysical modeling and imagery. His team used ground penetrating radar on the Mactaquac dam to determine the position of the interface between the concrete of this dam and the clay of the adjacent earth dam. New Brunswick Power needs this information for dam maintenance. His work within the Research Chair in Geological Sequestration of CO₂ focuses on developing methods of seismic, electric, and electromagnetic data processing and interpretation to be used both to map the physical properties of deep saline aquifers considered for storage and to monitor CO₂ injection in these aquifers.

Erwan Gloaguen's work is based on the stochastic integration of geophysical imagery measurements, with the objective of increasing our knowledge of soil properties for environmental, mining, or energy purposes. He is interested in multi-scale integration of imagery data, not only in geophysics but also in the biomedical field. Within the Research Chair in Geological Sequestration of CO₂, he focuses on potential reservoir characterization and modeling.

Bernard Long and his research team took seismic measurements in the northern channel of the St. Lawrence River off Île d'Orléans. The goal was to determine the nature and position of the different soil layers below the river. This work was part of two contracts: one for the construction of a new bridge and the other for the installation of an underground power line. They conducted another series of geophysical measurements in Mauritania (north-western Africa) in order to determine the thickness of sediments and the position of the bedrock for anchoring a new harbour infrastructure.

Hydrogeology

René Lefebvre's research program focuses on developing new approaches for aquifer characterization, with the objective of producing numerical models representative of real groundwater flow conditions and contaminant transport. His team continued to study the hydrogeology of the Valcartier sector (near Québec City) in relation to the presence of trichloroethylene (TCE) in groundwater as part of a permanent agreement for scientific and technical support with the federal government.

Dr. Lefebvre and his team continued their hydrogeological characterization work using hydraulic, geophysical, and geochemical methods and soundings by cone penetration in order to determine the migration and attenuation conditions of the leachate emitted by the abandoned Saint-Lambert-de-Lauzon landfill. This work is the result of an agreement with the agency responsible for managing the site. For the German company Wismut, they produced a numerical model of gas migration (radon in particular) in a remediated uranium tailing. The objective was to understand the migration of radon and to identify strategies to reduce its emissions. **Erwan Gloaguen** collaborated on these two projects.

René Lefebvre leads the Montérégie project within Quebec's program to foster knowledge about groundwater (PACES). Groundwater sampling, geophysical surveys, hydraulic tests, and drilling and installation of observation wells have been done or are underway. This team project includes the following researchers: **Erwan Gloaguen**, **Richard Martel**, and **Claudio Paniconi** from INRS and Christine Rivard and Michel Parent from GSC-Quebec.

Richard Martel's research interests relate to hydrogeological modeling of groundwater contamination caused by energetic materials (ammunition residues) from military training activities. He continued to work with his team on the characterization of groundwater contamination by updating the database and conducting fieldwork on the sites of different Canadian military bases in collaboration with Defence Research and Development Canada.

Claudio Paniconi's research program focuses on improving numerical models of hydrological processes at different scales. His team completed an Ouranos Consortium project aimed at modeling the interactions between surface water and groundwater at the watershed and subwatershed scales for the Châteauguay River. Participating colleagues were **René Lefebvre**, **Alain N. Rousseau**, and **Jean-Pierre Villeneuve** from INRS and Miroslav B. Nastev from GSC-Quebec.

Claudio Paniconi began a collaboration with an Italian team to promote exchanges of students and researchers on the topic of integrated hydrological modeling with the objective of improving management of water resources and analysis of the impacts of climate change. His team also collaborated with Tunisian and French researchers to develop a model of integrated management of water resources for a basin on the Cape Bon peninsula in Tunisia. Hydrological, hydrogeological, and water quality studies have been completed.

Claudio Paniconi's research team collaborates with others at INRS (**Norman Bergeron**, **Monique Bernier**, **Karem Chokmani**, **Taha B.M.J. Ouarda**) and with many other international teams on a large-scale project called CLIMB (CLimate Induced changes on the hydrology of Mediterranean Basins). The expected results will enable the evaluation of risks and vulnerabilities for freshwater resources in different regions of the world and the identification of suitable adaptation strategies.

Claudio Paniconi, **René Lefebvre**, and **Richard Martel's** teams are involved in the production of a guide on the design and installation of drinking water intakes located underwater and in river banks for Quebec's municipalities. This guide will be based on their previous work, a review of existing infrastructure, and laboratory tests.

Geological environments and natural resources

In the laboratory of physical, numerical, and geophysical simulation, **Lyal Harris** and his team use centrifuge modeling to develop channel flow models in orogens such as the Himalayas. They also

use sandbox modeling to better understand the geometry and evolution of structures in sedimentary basins, fold-thrust belts, and Archean terrains.

Dr. Harris is interested in the implications of structures in the deep crust and upper mantle for the location of mineral deposits and kimberlite emplacement in Canada, the United States, and the Iberian peninsula. He is also interested in the origins of seismic zones. With his team, he is developing a new tectonic model for the Grenville Province of Quebec and upstate New York. This model stresses the structural controls on mineralization. His colleague **Marc Richer-Laflièche** and Louise Corriveau of GSC-Quebec are collaborating on the latter project.

Lyal Harris has a few ongoing projects in Abitibi. He is collaborating with Jean H. Bédard (GSC-Quebec) on a team project focused on the regional geology of the Chibougamau area. They are also working together to develop new Archean tectonic models. Finally, he has started a new research project in the Desmaraisville area.

Michel Malo's research interests concern the development of rock porosity and permeability in orogenic fronts, with the objective of proposing a model for the evolution of the natural resource potential (hydrocarbons and metals) of these formations. He is the co-director of the DIVEX Network (www.divex.ca), which had its funding renewed in 2011.

His team is collaborating with GSC-Quebec researchers Patrick-Mercier Langevin et Benoît Dubé and the company IAMGOLD to define the geological and structural context of the Westwood deposit mineralized zones. This property contains major gold and other metals resources. The model developed for this deposit could be useful for exploration elsewhere in Abitibi.

Dr. Malo is collaborating with Denis Lavoie of GSC-Quebec on a project about source rock potential and thermal maturity in the Hudson Bay area that includes analysis of five soundings distributed throughout the Foxe Basin. His team has other ongoing work on thermal maturity, source rock potential, and structural geology in the Gaspésie region. Their project in that region on 3D modeling of hydrocarbon reservoirs and evaluation of their petroleum potential, done in partnership with the company Pétrolia and the French Petroleum Institute, was completed during the year. Denis Lavoie and Nicolas Pinet, researchers at GSC-Quebec, were involved in the latter project.

Michel Malo holds the Research Chair in Geological Sequestration of CO₂ (chaireco2.ete.inrs.ca), exploring the main options for the geological storage of CO₂ in Quebec. His colleagues involved are **Bernard Giroux**, **Erwan Gloaguen**, **René Lefebvre**, **Marc Richer-Laflièche**, and **Normand Tassé**; Mathieu J. Duchesne from the GSC-Quebec is also involved.

Marc Richer-Laflièche has several ongoing projects funded by J.A.G. Mines. With his team, he is documenting the characteristics of the polymetallic deposit of Saint-Robert Bellarmin in the Beauce region. Electromagnetic, geoelectric, magnetometric, and

gravimetric surveys have been conducted in order to model the presence of an intrusive body below the mineralized zones and to study the hydrothermal alteration structures.

In Lac-Saint-Jean, terrestrial gravimetric surveys carried out to the west of the lake helped determine the nature of the geological formations located underneath the quaternary marine deposits. An aquatic magnetometric survey enabled mapping of the magnetic contrasts and helped to shed light on the geology of the basin. With the objective of documenting the geoelectric properties of the basin between 0 and 1500 m, a 30-km-long survey was conducted on the frozen lake surface. This is the longest survey of its kind ever done.

Dr. Richer-Lafleche and his team continued to work east of Lake Témiscouata. The geophysical and pedogeochemical surveys conducted helped explain the origin of the natural gas concentrations present in the soils of this region. In Charlevoix, a geophysical study of the quaternary formations and bedrock of the Gouffre Valley was done to determine the distribution of the geological units masked by the marine clays that cover the entire valley.

Pierre-Simon Ross and his team are particularly interested in mineral deposits associated with volcanic or magmatic activity such as volcanogenic massive sulphide deposits (Cu, Zn, Au, Ag), porphyry systems (Cu, Mo, W, Au), and kimberlites (diamonds); they are also interested in the geological environment of such deposits. They are working towards a better understanding of maar-diatreme volcanoes and kimberlites. In collaboration with UQAM researchers, they are studying porphyritic mineralizations in the James Bay region.



Hopi Buttes volcanic field, Arizona

Dr. Ross's team is participating in two projects in the Matagami area. The first one is a study of the volcanic architecture of the Matagami Mining Camp in partnership with industry. The implications for the search for volcanogenic massive sulphide deposits are considered. In the second project, the Mobile Laboratory for Physical, Mineralogical, and Chemical Characterization of Rocks (LAMROC) is being used to set up and develop a large, multiparameter data bank for the area.

Paleoenvironmental studies

Yves Bégin's research interests relate to the reconstruction of historical floods and low water levels at the boreal-subarctic interface using natural archives (tree rings and paleosoils). His team continues to work on the ARCHIVES (archives.ete.inrs.ca) project in collaboration with **Pierre Francus**, the Ouranos Consortium, the ArcticNet Network, and the Centre d'études nordiques. Their objective is to document the hydrological and climatic variations of the last 1000 years in Quebec's boreal zone. Christian Bégin and Martine M. Savard from GSC-Quebec and several other researchers from Quebec and Europe are participating in this project.

The research program of **Pierre Francus** focuses on the reconstruction of past climates using annually laminated lake sediments, mostly in the Canadian Arctic, in order to anticipate future changes related to global warming. He completed his contribution to two group projects during the year. The first was an integrated study of High Arctic watersheds based at the Cape Bounty Field Station in Nunavut and funded by the International Polar Year. In the second project, a team of researchers led at Laval University examined the greenhouse gas emissions from thermokarst lakes created by permafrost melting in Northern Quebec.

Dr. Francus is also participating in a group project led at UQAM that documents past warm climatic periods (interglacials) at high latitudes to use the data in climate simulation models. This work is part of the Past4Future project funded by the European Commission.

Finally, he leads the Canadian contributions to two international initiatives: PASADO (Potrok Aike Maar Lake Sediment Archive Drilling Project, can-pasado.ete.inrs.ca), in which past environments are reconstructed using drill cores from a Patagonian lagoon, and ICDP-Canada (International Continental Scientific Drilling Program, www.icdp-canada.ca).

Environmental decontamination and waste reclamation

Environmental decontamination

The research program of **Jean-François Blais** concerns the treatment of solid and liquid matrices polluted by toxic metals and other contaminants. He holds the Canada Research Chair in Environmental Decontamination, which focuses on developing two types of processes: 1) decontamination of matrices polluted by metals and other contaminants, and 2) stabilization, conditioning, and separation of different biomasses.

Jean-François Blais, Guy Mercier, and Patrick Drogui's research teams continued to work on the decontamination process they have developed for chromated copper arsenate-treated wood in collaboration with researchers from the University of Toronto.

Patrick Drogui's research program focuses on the use of electro-technologies in water treatment to remove endocrine-disrupting

chemicals and other pollutants. With his team, he is collaborating with researchers from France, Morocco, and Tunisia on the development of electrolytic and membrane technologies to treat wastewater contaminated with organic and inorganic micropollutants. In a contract for the company Filter Innovation, they carried out preindustrial pilot tests of the electrocoagulation/electrofloculation (EC-EF) treatment process for different types of effluents. The aim was to demonstrate its effectiveness for potential commercial applications.

In addition, the teams of **Patrick Drogui**, **Jean-François Blais**, and **Guy Mercier** are involved in a partnership with the company Premier Tech to develop independent electrolytic units to treat residential wastewater.

Patrick Drogui has completed the first phase of a project for Quebec Ministry of the Environment aimed at developing a treatment process for groundwater contaminated by leachate from a leaking landfill containing hazardous waste. Three treatment combinations have been tested in the laboratory to evaluate their environmental and economic performance. **Jean-François Blais** collaborated on this project.

Guy Mercier's research interests concern the development of treatment processes for soils and municipal and industrial waste contaminated both by metals (which can be reclaimed) and by hydrophobic organic compounds (HOC).

Guy Mercier collaborated with **Jean-François Blais** in developing Organometox, a single-step process to treat soils contaminated by both metals (extracted using chemical leaching) and polycyclic aromatic hydrocarbons (removed using a new type of surfactant). The technology has recently been transferred to the company Tecosol. A demonstration of this green technology has been funded by Tecosol and the Quebec government. It consists of a small-scale soil treatment plant located on the site of Canadian Forces Base Valcartier.

These two researchers' teams collaborated on a project in partnership with industry to develop treatment strategies for problematic effluents and to determine the best microbial strain to be used. They also continued to work on a mineral carbonation process for ultrabasic residues from the asbestos industry. These residues are rich in cations able to react with CO_2 to form carbonates. This represents a promising way of reducing greenhouse gases by trapping CO_2 directly from industrial emissions.

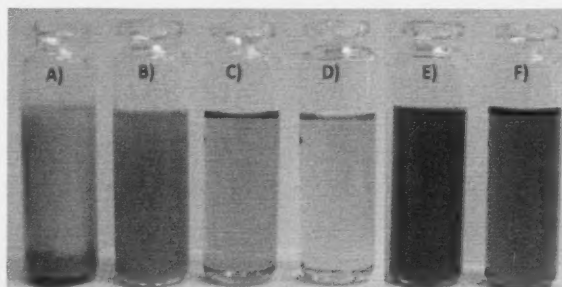
Waste and biomass reclamation

Mario Bergeron's research team continued the development of a new production process for chlorosilanes. These siliceous compounds are the base material used in the optical fibre, solar panel, semiconductor, and pyrogenic silica industries.

Satinder Kaur Brar's research interests relate to the decontamination and reclamation of wastewater and sewage sludge polluted

by toxic organic compounds. For example, one compound for which treatments have been tested is BPA (bisphenol A). BPA was entirely removed from sewage sludge only after the last step of the treatment, that of biofertilizer production. Her team also carried out a project on reclamation of residues of the fruit-processing and juice-producing industry to obtain value-added products such as ligninolytic enzymes, antioxidants, and a residual biomass that can be added to animal food. **Rajeshwar Dayal Tyagi** collaborated on the latter project.

Satinder Kaur Brar started two new projects, one in collaboration with a microbrewery in Québec City and the other as part of an international cooperative effort. In the first project, new bio-flocculants are being tested to separate solid from liquid during beer production. This step is crucial in the process since the taste and aroma of the end product must not be compromised. Economically interesting bioflocculants have been identified and pilot tests are underway.



Flocculation and clarification of microbrewery fermented broth. A) Control (fermented broth), B) after treating with Stabifox, C) chitin treatment, D) chitosan treatment, E) treatment with polyphenols, and F) treatment with chitin after 48h

In the second project, Dr. Brar is collaborating with researchers from the laboratory of biotechnological processes of the University of Paraná in Brazil to produce hydrogen-based biofuels using micro-organisms from agro-industrial residues. The exchange with the Brazilian partners will contribute to the development of biofuels in Quebec, where the residues of the fruit, potato, and animal (glycerol) transformation industries could be used to produce biohydrogen.

Rajeshwar Dayal Tyagi's research program focuses on sewage sludge decontamination and reclamation to produce value-added products. He holds the Canada Research Chair on the Bioconversion of Wastewater and Sewage Sludge into High-Value-Added Products.

Dr. Tyagi and his team continued to work in partnership with industry to obtain proteins from whey that can be added to animal food. They seek to optimize the extraction process and improve the end product. They also started a new phase in the development of formulations of the biopesticide Bt (used to control spruce budworm in forests) using starch industry wastewater. The formulations will be tested at the pilot and industrial scales. **Satinder Kaur Brar** is collaborating on these two projects.

Centre - Eau Terre Environnement

The Centre's high-tech laboratories and specialized equipment combine with its researchers' high level of expertise to contribute to the Centre's mission of education, applied research, and innovation.

The Centre's main infrastructure comprises modern research laboratories, pre-industrial-scale laboratories, mobile facilities, and a research station.

The **research laboratories** are located in a downtown building on the urban campus of the Université du Québec in Quebec City. They include a very complete set of analytical equipment essential for advanced research work, and extensive modeling and data processing capacities. For example, the Centre possesses a class 1000 clean room with a class 100 workspace, controlled environmental chambers, and the necessary equipment to prepare geological samples.

The **large-scale laboratories** are located in the Metropolitan Quebec Technology Park. Among other purposes, these laboratories are used for the scaling of technologies developed in partnership with industry. The pre-industrial experimental equipment is used to analyse the economic viability of technological innovations. These laboratories constitute a major asset for Quebec and Canadian enterprises.

The Centre also has **mobile facilities** enabling on-site specialized work in environmental decontamination, hydrogeology, and geological analysis.

A **research station**, located at Sacré-Cœur in the Saguenay region near the mouth of the Sainte-Marguerite River, offers the Centre's research teams a workspace in a natural environment of exceptional quality. The station comprises a laboratory and accommodations for up to 30 persons.

These facilities support applied innovative research related to hydrology, biogeochemistry, geological sciences, and environmental decontamination and waste reclamation.

These powerful tools for innovation and the Centre's high level of expertise are accessible to enterprises and governments via collaborative research projects oriented towards their specific needs. The Centre thus offers an exceptional opportunity for economic actors and regulatory agencies to contribute to the improvement of knowledge while serving their respective missions.



Large-scale laboratories in the Technology Park



Research station in the Saguenay region

FOR MORE INFORMATION, PLEASE CONTACT:

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RESEARCH LABORATORIES

The research laboratories comprise a general laboratory and several specialized laboratories as well as microscopy and sample preparation rooms. The specialized laboratories enable the analysis of water samples by colorimetry, fluorometry, radio-isotopy, and chromatography, the analysis of organic compounds and trace metals contained in various matrices (water, effluent, sewage sludge, soil, sediment, biological tissues), and the analysis of different elements contained in solid samples (rock, soil, sediment, sludge). The Centre's analytical equipment and specialized software contribute to experimental research in a variety of fields.

FOR MORE INFORMATION, PLEASE CONTACT:

Stéfane Prémont, head of laboratory services, stefane.premont@ete.inrs.ca

X-ray fluorescence scanner

A non-destructive tool for chemical analysis by XRF (X-ray fluorescence) scanning and micro-radiography analysis of rocks and sediment cores

The **ITRAX™** core scanner enables the simultaneous acquisition of very high resolution (100 µm) data on density, structural, and compositional variations of samples; it can also conduct optical imaging. Most elements can be measured using XRF, from aluminum to uranium. Rocks, powder, and split sediment cores and U-channels of up to 1.8 m in length can be analysed.

One of the uses of this equipment is to analyse lake and marine sediments in order to reconstruct past climates at various temporal scales.



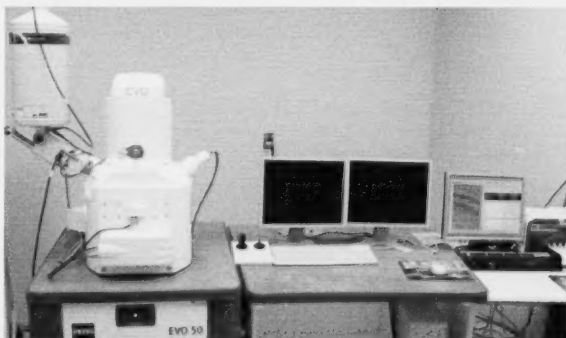
| ITRAX™ XRF core scanner

Scanning electron microscope

Based on the interactions between electrons and a sample's atoms, this technology enables high-resolution imaging of the surface of a sample

Using the **Zeiss EVO® 50** scanning electron microscope (SEM), it is possible to obtain images of the surface of most solid materials, with magnifications from 100X to 60 000X.

The SEM is equipped with three types of detectors for various applications: morphological characterization (secondary electron detection), phase atomic density and granulometry (back-scattered electron detection), and chemical composition analysis and elemental distribution mapping (x-ray detection). The SEM can be used to observe samples in controlled-pressure environments, eliminating the need for preliminary metallization.



| Scanning electron microscope (SEM)

CONTACT:

Dr. **Pierre Francus**, pierre.francus@ete.inrs.ca

Aquatic biogeochemistry and limnology

Analysis of trace metals in liquid or solid samples (biological tissues, suspended matter, sediment, soil) and bio-optical analysis

The main instruments used for trace metal analysis are:

- Radioactivity and particle counters (beta and gamma emissions)
- Atomic absorption spectrophotometer (combined flame and graphite furnace)
- Inductively coupled plasma atomic emission and mass spectrometers (ICP-AES and ICP-MS)
- Liquid, gas, and ion chromatography systems (HPLC, LC-MS-MS, GC, GC-MS)
- Mercury analyzer

These instruments support research on the transfer of toxic metals within food chains, the bioavailability of contaminants, the impacts of anthropogenic activities, and the sensitivity of the natural environment to metal contamination.



Gas chromatography system

Limnology work focuses on the impacts of climate change on water mixing dynamics and transparency in lakes, and on their interaction with the microbial food chain. Bio-optical work focuses on counting and characterizing microorganisms, monitoring their fluorescence, describing their morphometry and taxonomy, and studying their physiology.

CONTACT:

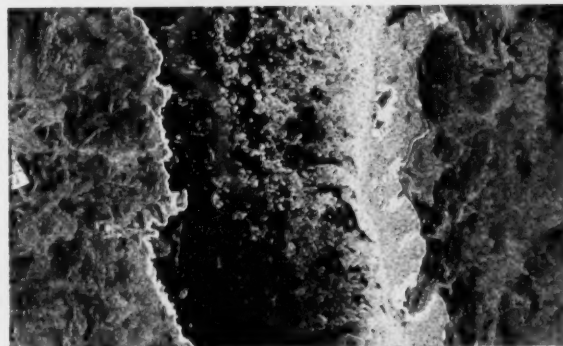
Stéfane Prémont, stefane.premont@ete.inrs.ca

Applied remote sensing

Analysis of earth observation images to map and model different processes, particularly those related to water resources in northern environments

Satellite radar (RADARSAT, ASAR, TerraSAR-X) and optical (GeoEye, Quickbird, Ikonos, NOAA) imagery enables researchers to develop applications to measure and monitor water resources, the cryosphere (snow, ice, frozen soil), and wind resources. The Centre possesses several hundred images along with specialized software to process and analyse those images (Geomatica®, eCognition, ArcGIS, and MATLAB®).

Field measurements (with snow sampler, georadar, GPS and camera, weather stations, and moisture probes) are used to calibrate and validate the algorithms developed.



RADARSAT-2 image centred on Kuujuaq harbour (© MDA and Canadian Space Agency)

CONTACTS:

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Dr. **Karem Chokmani**, karem.chokmani@ete.inrs.ca

Hydrology

Several hydrological modeling software programs have been developed by the Centre's researchers for specific needs. Field work is also an important component of hydrology research.

Hydrological numerical models to assist statistical analysis and river hydraulic studies

HYFRAN: HYFRAN is a statistical adjustment software program that includes a whole set of mathematical tools for the statistical analysis of data series, including, in particular, the statistical analysis of extreme events.

www.ete.inrs.ca/activites/groupe/chaire_hydrol/chaire9.html

H2D2/MODELEUR: H2D2 is a finite-element software program that is modular and extendable for applications in river hydraulics. It can be used coupled to MODELEUR (a specialized GIS). H2D2 is used in studies related to civil engineering, navigation, sediment transport, and the availability of fish habitats, among other issues.

www.gre-ehn.ete.inrs.ca/H2D2

Hydrological numerical models to assist surface water management at the watershed scale

HYDROTEL/PHYSITEL: HYDROTEL is a distributed hydrological model combining remote sensing data and geographic information system (GIS) data. This model can simulate a whole set of hydrological processes. PHYSITEL, a specialized GIS, enables database formatting for various distributed hydrological models. In the context of sustainable development and climate change, the demand for such tools is increasing in order to better predict inflows to hydroelectric reservoirs and maximum flood levels (for dam safety). These tools are also used to study the role of wetlands within the hydrological cycle of watersheds.

www.ete.inrs.ca/activites/modeles/hydrotel/en/accueil.htm

GIBSI: GIBSI is an integrated modeling and data management system for watersheds that includes a database management system and a GIS. It supports decision-making by enabling water managers to explore different strategies at the watershed scale (e.g., assessment of beneficial management practices in agriculture; management of contamination risks for drinking water sources).

Boreal hydrology *in situ* measurements

Experimental research in boreal hydrology includes analysis of water retention, hydraulic conductivity, and infiltration properties in soil columns and samples using laboratory setups (tension tables, disk and double disk infiltrometers, and infiltration columns). It also includes the study of water flows, hydrological balance, and isotope presence at the scale of peatlands and watersheds using field measurements (water table levels, weather data, and trapezoidal channel experiments).



Monitoring of water flows in a peatland

CONTACT:

Dr. **Alain N. Rousseau**, alain.rousseau@ete.inrs.ca

LARGE-SCALE LABORATORIES

These laboratories host the larger research equipment not compatible with conventional laboratories and applied research pre-industrial units that require a more robust work environment.



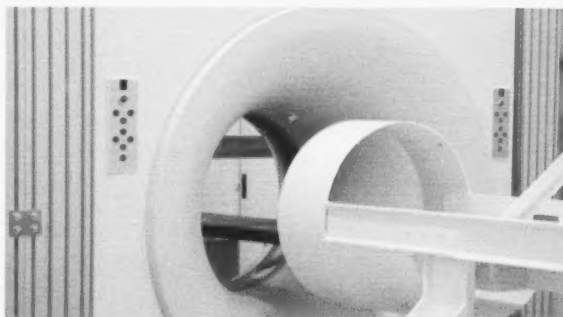
Computer tomography scanner

Non-destructive measurements of the interior of natural or artificial solid bodies using density microvariations to determine the internal structure, the fracture and microfissure networks, the porosity, and the homogeneity of the analysed bodies

This modified medical equipment enables 3D study of fluid structures and flows within a volume created from repeated sequences of 64 simultaneous images with submillimetre precision and sensitivity to density variations of 0.1%.

This equipment possesses several features that give it flexibility for different applications. The **Siemens SOMATOM Sensation 64** scanner is installed on 3.5-m-long rails and has a 70-cm-diameter opening and source/sensor pairs enabling 360° measurements around the analysed body. The facility also includes instruments such as a laser granulometer, aquariums and pressure compartments to measure bioturbation, and a hydraulic channel to reproduce one-way currents, swell and gravity movements. This channel comprises instruments such as PIV, ADCP and ADV current profilers, resistivity probes, OBS, and cameras.

This equipment can be useful for numerous research fields: marine engineering, geological engineering, hydrogeology, sedimentary dynamics, environmental studies, dendrochronology, micropaleontology, biology, marine ecology, biogeochemistry, metallogeny, petrography, and archaeology.



| SOMATOM Sensation CT scanner

CONTACT:

Dr. **Bernard Long**, bernard.long@ete.inrs.ca

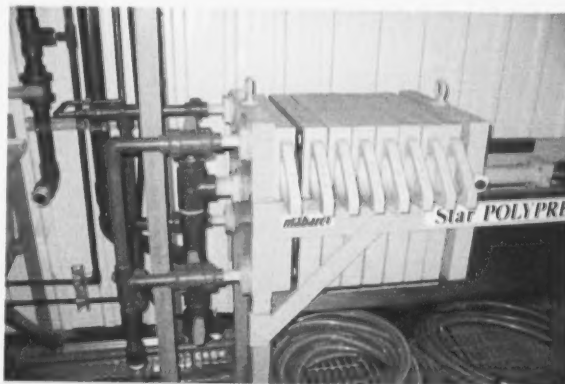
Decontamination

Implementation of environmental technologies at a pre-industrial scale to develop or optimize decontamination methods for liquid and solid residues using chemical, physical, biological, and electrochemical processes

Different modular units can be assembled to develop treatment methods adapted to specific decontamination needs. Liquid residues that can be treated include contaminated groundwater and municipal, industrial, and agroalimentary wastewater. Decontamination processes for solid residues can apply to soil, industrial waste, hazardous material, and sewage sludge. Some experimental setups can address complex issues such as mixed contamination or contamination implying refractory pollutants.

The main modular units are:

- Lamellar clarifier
- Bioflotation/biofiltration/membrane bioreactor
- Filter press
- Tray filter
- Centrifuge
- Rotary ring press
- Ion exchanger
- Adsorption column
- Electro-oxidation and electrodeposition unit
- Electrocoagulation and electroflotation unit
- Electromembrane unit
- Membrane units (microfiltration, ultrafiltration, nanofiltration, reverse osmosis)
- Voltamperometric unit (galvanostat/potentiostat)
- Screening unit
- Magnetic separator
- Shaking table
- Fluidized bed
- Flotation cell



Filter press for sludge dewatering

CONTACTS:

Dr. **Jean-François Blais**, jean-francois.blais@ete.inrs.ca

Dr. **Patrick Drogui**, patrick.drogui@ete.inrs.ca

Dr. **Guy Mercier**, guy.mercier@ete.inrs.ca

Bioprocesses

Small-scale implementation of the main steps of biological transformation of waste in order to develop or optimize processes used to obtain added-value products

All steps of the conversion process can be carried out using modular units, including conditioning of the raw material, waste transformation, and recovery of the end product. The equipment, installed in a food-grade workspace, is used to develop, optimize, and scale new bioprocesses. The added-value products obtained can be biopolymers, biopesticides, biofertilizers, biofuels, antioxidants, enzymes, and proteins.

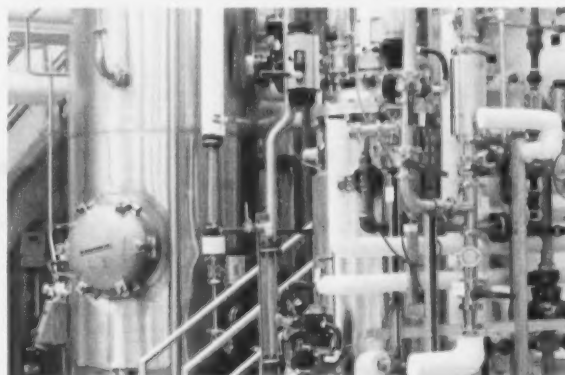
Two hydrolyzers (of 150- and 2000-litre capacity) are used to prepare the culture medium. For fermentation, the facility includes two instrumented fermentation lines, each having its own bioreactors (of 5-, 15-, 150-, and 2000-litre capacity).

The last step, recovery of the end product, uses the following modules:

- Continuous centrifuge
- Microfiltration and ultrafiltration unit
- Protein separation system using chromatography and ion exchange
- Spray dryer to obtain powder or granules
- Freeze dryer

The main analytical instruments used are:

- Flow cytometer
- DNA thermal cycler
- Electrophoresis system



2000-litre capacity hydrolyzer

CONTACT:

Dr. **Rajeshwar Dayal Tyagi**, rd.tyagi@ete.inrs.ca

Soil and groundwater contamination

Study of soil contaminant behaviour and development of *in situ* treatment procedures at a scale intermediate between the laboratory and the field

The following equipment is used to simulate groundwater flows, monitor contaminant transport, and test new decontamination technologies for soil and groundwater, particularly for refractory contaminants or complex contamination contexts:

- Two reservoirs of 4 and 9 m³ to test *in situ* decontamination technologies equipped with injection, pumping, and sampling wells
- Stainless steel columns to test different passive methods (natural attenuation, reaction wall)
- Stainless steel column segments to compare different active methods (air sparging, venting, biodegradation, soil washing with surfactants, and chemical oxidation)
- Laboratory cooled to groundwater temperature (8 °C)



Monitoring of contaminant transfer through soil columns

CONTACT:

Dr. **Richard Martel**, richard.martel@ete.inrs.ca

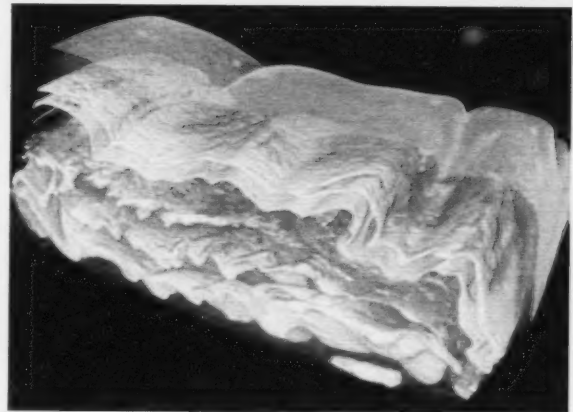
Geodynamics

Structural and tectonic interpretation of field and geophysical data and simulation of geological processes to assist mineral and oil prospecting

Field studies and advanced geophysical data processing combined with physical, numerical, and geophysical simulations enable researchers to interpret the geometry and evolution of geological structures and to identify the structural and tectonic controls of mineral deposits and oil traps. The progressive deformation of the physical simulation models can be observed using tomodesitometry.

The main equipment includes:

- Work stations equipped with interactive screens and specialized software for geophysical data processing (Oasis Montaj™ and GM-SYS 2D extension, Geosoft), geotechnical 2D analysis (UDEC™ 5.0, Itasca), 3D reconstruction (GOCAD®, Gocad Research Group), and PIV imagery (StrainMaster, LaVision)
- Sandboxes, which are used to perform deformations (controlling for speed and constraints) to simulate brittle and brittle-ductile deformation of rocks, effects of basement structure, and pluton formation
- High-speed centrifuge, which enables the scaling of deformation models (made of plasticine and silicone mastic) to simulate the ductile deformation of rocks and diapirism



3D image of a model of folding in a channel flow

CONTACT:

Dr. **Lyal Harris**, lyal.harris@ete.inrs.ca

MOBILE FACILITIES

These facilities are used to carry out on-site tests and analyses. A modified truck serves as a biogeochemistry laboratory to prepare and process field samples directly on-site.

Environmental technologies

Testing decontamination technologies in real conditions

This mobile facility is used to test a whole set of decontamination technologies directly on the sites where the wastewater or contaminated soils are produced. The trailer can accommodate various treatment units that can be specifically assembled to meet different decontamination needs.



Mobile decontamination laboratory

CONTACTS:

Dr. **Jean-François Blais**, jean-francois.blais@ete.inrs.ca

Dr. **Guy Mercier**, guy.mercier@ete.inrs.ca

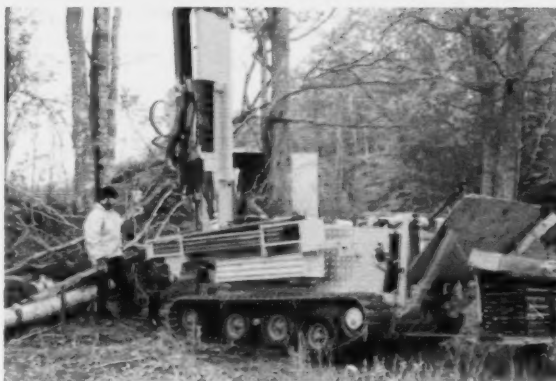
Aquifer characterization

Development of detailed characterization techniques for aquifers in the field to assist numerical modeling

The main equipment used to characterize the physical and geochemical properties of aquifers is a Geotech 605 drilling and sounding rig. Data collected with this equipment enable researchers to model flows and contaminant transport within aquifers. Researchers are also able to evaluate aquifer sensitivity to contamination and determine the most appropriate protection and exploitation strategies for sustainable management of the groundwater resource.

This crawler-mounted rig can simultaneously record several data parameters, enabling the identification of materials and determination of their mechanical and electrical responses and porosity. It can be used for soil or groundwater sampling, eliminating the need for permanent observation wells. The system can also be used to install observation wells by penetration (without drilling).

One of the spindles can be used to make soundings by cone penetration (CPT) up to 30 m deep in loose sediments, and the other is equipped with a pneumatic drill to make soundings by rotary percussion up to 50 m deep in rocks and in sediments.



GEORIG 605 in the field

CONTACT:

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Characterization of rocks

Automated system for simultaneous measurements of several properties on diamond drill cores – An innovation for mineral exploration

The system is installed in a mobile trailer. Cores placed on a conveyor successively pass through the following sensors that measure the main physical, mineralogical, and chemical properties of the rock:

- High resolution camera
- Gamma densimeter
- Laser (to measure thickness)
- Infrared and visible spectrometer
- Magnetic susceptibility meter
- X-ray fluorescence spectrometer (XRF)
- Electrical conductivity meter

Several portable instruments are also available to measure the physical properties of rocks in the field (magnetic susceptibility, density, electrical conductivity, gamma radiation).



Automated system for characterization of rocks

Measurements of rocks' physical properties can be useful for planning and interpreting geophysical surveys. Geochemical measurements using high-resolution XRF can be used to locate cryptic geological contacts and to quantify hydrothermal alteration, among other tasks. Identification of mineral alteration can be done using infrared and visible spectrometry.

Multivariate statistical analysis of collected data can help to better identify the different geological units. The ultimate objective of this new system is to obtain as much information as possible from drill cores directly on the extraction site.

CONTACT:

Dr. **Pierre-Simon Ross**, pierre-simon.ross@ete.inrs.ca

Publications

Journal of Water Science

www.rse.inrs.ca

An international electronic journal co-edited with the Groupement d'intérêt scientifique des sciences de l'eau (France).

Scientific publications

The annual listing of the publications and communications of the Centre's researchers is available online:

www.ete.inrs.ca/ete/publications

Most of the Centre's research reports and graduate theses are available online:

www.ete.inrs.ca/ete/publications/rapports

www.ete.inrs.ca/ete/publications/theses-memoires

Capsules INRSciences

[www.ete.inrs.ca/ete/publications#Capsules INRSciences](http://www.ete.inrs.ca/ete/publications#Capsules%20INRSciences)

Information bulletins highlighting in easily understood language the research carried out by students from the Centre.

Meetings and seminars

Seminar program

The Centre holds scientific seminars related to its various research fields throughout the year.

Conferences, meetings, and workshops

July 5–7, 2010: *Water 2010 – Hydrology, Hydraulics and Water Resources in an Uncertain Environment*, Joint ISSH (International Symposium on Stochastic Hydraulics) and ICWRER (International Conference on Water Resources and Environmental Research) Symposium organized in Québec City by Professor Taha B.M.J. Ouarda with the collaboration of several colleagues at the Centre.

March 21–23, 2011: 3rd International PASADO (Potrook Aike Maar Lake Sediment Archive Drilling Project) Workshop organized in Montréal by Professor Pierre Francus.

April 28, 2011: *CO₂ Monitoring at Injection Sites: the Weyburn-Midale Case*, 3rd annual meeting of the Research Chair on the Geological Sequestration of CO₂ organized at the Centre by Professor Michel Malo.

chaireco2.ete.inrs.ca/?q=en/colloque_2011_eng



Professor Taha B.M.J. Ouarda (left), organizer of the international conference Water 2010, with some participants.

Research excellence

Several members of the Centre received awards this year for the excellence of their research or the quality of their scientific communications.

In September 2010, Professor Rajeshwar Dayal Tyagi received the Global Honour Award for Applied Research from the International Water Association. This international award recognizes Dr. Tyagi's achievements in the development of bioprocesses to treat and reclaim wastewater and sewage sludge. His work in partnership with the HET Corporation and the Perron cheese factory was honoured at the *Célébrons le Partenariat* event organized by the Quebec Association for Industrial Research in collaboration with NSERC.

Professor Richard Martel, Angus Calderhead (2009 PhD graduate), and co-authors received the award for the best article published in 2010 in the *Canadian Journal of Remote Sensing*.

Claudie Beaulieu, 2009 graduate in Water Sciences (Dr. Ouarda's team), received the 2010 excellence prize for the best PhD thesis in sciences and engineering awarded by the Quebec Association of Deans of Graduate Studies in collaboration with FQRNT.

Russel Rogers, 2010 graduate in Earth Sciences (Dr. Ross's team), received the 2011 Léopold-Gélinas Silver Medal awarded by the Geological Association of Canada to honour the best Master's thesis in the field of volcanology and igneous petrology.

At the INRS convocation ceremony on 30 October 2010, four students at the Centre were honoured. Dominic Ponton (Dr. Hare's team) and Jérôme Dubé (Dr. Normand. Bergeron's team) received the awards for the best Master's thesis in Water Sciences and Earth Sciences, respectively. Raoul-Marie Couture (Dr. Gobeil's team) received the award for the best PhD thesis in Water Sciences. Kokou Adjallé, 2009 PhD graduate (Dr. Tyagi's team), received the INRS Innovation Award for his contribution to technology transfer to industry.

At the first meeting of *Les eaux souterraines au Québec*, held in October, two PhD students, Martin Blouin (Dr. Gloaguen's team) and Jean-Sébastien Gosselin (Dr. Martel's team), respectively received the best oral presentation and best poster awards.

Finally, at the ArcticNet Annual Conference in December, Masters' student Jessy Barrette (Dr. Gratton's team) took second place in the poster contest in the category: Natural sciences – Ocean.

Public outreach

Researchers at the Centre regularly give interviews and contribute to articles in the media (newspapers, radio, television, Internet) within their specialty field.

The summer of 2010 saw the return of public concern about cyanobacterial blooms in lakes. In August, professors Patrick Drogui, Isabelle Laurion, and Alain N. Rousseau gave interviews on the subject to Radio-Canada journalists (radio and television).

Shale gas was the hot topic during the fall. In October, Radio-Canada's science radio show *Les Années lumière* interviewed Professor René Lefebvre on groundwater resources for a report on shale gas. Structural geologist Michel Malo's expertise on shale gas was sought out on several occasions by the media (Channel V, Radio-Canada) and for two articles published in November, one in the professional journal of Quebec's engineers and the other in *Québec-Science*. Dr. Malo was also one of the panel experts of the BAPE Commission on sustainable development of the shale gas industry in Quebec.

In mid-November, after the announcement that the Organométex process developed at the Centre had obtained a grant for green technologies demonstration, Professor Guy Mercier gave several interviews to the media (newspapers and television).

The work of two of the Centre's researchers was highlighted on the web during the year. In November, C&EN (Chemical & Engineering News) had a news about a recently published scientific article by Professor Paul Drevnick on the biogeochemistry of Arctic lakes. In December, the work of Professor Pierre Francus about the gradual drying of the Sahara was the subject of an article in *Astrobiology Magazine*, a NASA-sponsored online popular science magazine. The article also appeared on the NASA website and in the online newspaper *The Huffington Post*.

In February 2011, the FQRNT Annual Research Day was held in Trois-Rivières on the theme of the St. Lawrence River. The local newspaper *Le Nouvelliste* published an article about Professor Patrick Drogui's presentation of his work at the event.

Finally, in April, Master's student Carole-Anne Gillis (Dr. Norman Bergeron's team) was interviewed twice about her study subject, the invasive seaweed *dydimos* (for the newspaper *Le Soleil* and for Radio-Canada).

Training of highly qualified personnel

Six graduate programs are offered at the Centre Eau Terre Environnement. The inter-university Master's and PhD programs in earth sciences are operated in collaboration with the Geology and Geological Engineering Department of the Université Laval. The students are registered in the institution of their supervisor but are trained by both institutions.

Graduate studies

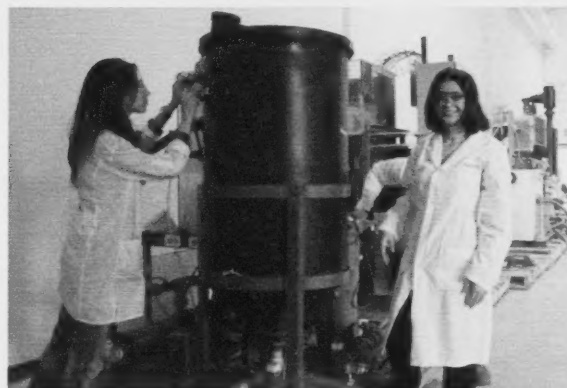
www.inrs.ca/english/research-centres/ete/graduate-studies

Master's degrees

- Master's in Water Sciences
- Professional Master's in Water Sciences
- Master's in Earth Sciences
- Professional Master's in Earth Sciences – Environmental Technologies

PhD degrees

- PhD in Water Sciences
- PhD in Earth Sciences



Intern Asmaa Errachidi and PhD student Rimel Dahmir, Environmental Electrotechnologies and Oxidative Processes Laboratory

Internships and fellowships

The Centre Eau Terre Environnement welcomes postdoctoral fellows in its research groups. INRS postdoctoral scholarships are available. The Centre also offers undergraduate summer internships, an excellent opportunity for students to gain research experience in a highly stimulating scientific environment.

INRS postdoctoral fellowships:

www.inrs.ca/english/graduate-studies/postdoctoral-fellowship

The Centre's summer internships:

www.ete.inrs.ca/ete/etudier/projets-etudes-stages (in French)

Research and teaching

Research teams

Jean-Christian Auclair (P) Limnology and aquatic geochemistry

Yves Bégin (P) Dendroecology

Joëlle Marion (O)
Antoine Nicault (As)
 Mathilde Renaud (At)
 Cristian Alvarez (MSc)
 Nanie Ayotte (MSc and I)
Philippe Boulanger (MSc)
 Yves Bouthilier (MSc)
 Thibault Labarre (MSc)
 Pierre-Paul Dion (I)

Mario Bergeron (P) Mineral and environmental chemistry

Marie Létourneau (T)
 Alain Langlais (O)

Normand E. Bergeron (P) Fluvial geomorphology

Francis Bérubé (T)
Dominique Lapointe (As)
 Marc-André Pouliot (At)
Maxime Rousseau (At)
 Stephen Dugdale (PhD)
 Elsa Goerig (PhD)
 Patricia Johnston (PhD)
 Jean-Baptiste Torterotot (PhD and At)
Jean-Nicolas Bujold (MSc)
Joanie Côté (MSc)
 Carol-Anne Gillis (MSc)
 Maxime Grenier (MSc)
Maxim Fortin (I)
Anne St-Pierre Provencher (I)
André Boivin (Field station supervisor)

Monique Bernier (P) Remote sensing

Yves Gauthier (O)
 Jalal Khaldoune (As)
 Clément Clerc (At)
 Jimmy Poulin (At)
 Andrès Jacome (Postdoc)
 Maria Dissanska (PhD)
 Yannick Duguay (PhD)
 Rebecca Filion (PhD)
 Kim Huong Hoang (PhD)
 Parvin Kalantari (PhD)
Stéphane Mermoz (PhD)
 Marion Tanguy (PhD)
 Thomas Bergeron (MSc)
 Stéphanie Bleau (MSc)
 Stéphane De Munck (MSc and I)
 Charles Gignac (MSc)
 Karine Labrecque (MSc)
Audrey Lessard-Fontaine (MSc)
Jean-Simon Bédard (I)
Florian Lafage (I)

Jean-François Blais (P) Environmental decontamination

Myriam Chartier (O)
 Jihen Ben Khaled (PhD)
 Lucie Coudert (PhD)
Samuel De la Rochebrochard (PhD)
 Dikenane Kombila (PhD)
 Stéphanie Lafond (PhD)
 Nicolas Reynier (PhD)
Pascal Castellazzi (MSc)
Marie-Christine Simard (MSc)
Karima Cheggari (I)
Céline Dam Hieu (I)
Soumia El Basri (I)
Mathieu Renouard-Opigez (I)
Adil Rhazzar (I)

Bernard Bobée (Emeritus P) Statistical hydrology

Nader Jmour (I)
Ouejdene Samoud (I)

Satinder Kaur Brar (P) Bioconversion and emergent contaminants

M. Ajila Chandran (Postdoc)
 Gurpreet Singh Dhillon (PhD)
 Fatma Gassara (PhD)
 Dipti Mohapatra (PhD)
Daphné Champenois (I)
Julie Com (I)
Audrey Dehors (I)
Ibtihel Frouja (I)
Émilie Helouis (I)
 Surinder Kaur (I)
Kalifa Keita (I)
 Sabrine Metahni (I)
Carole Miegé (I)

Abbreviations

P: Professor-Researcher
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 PhD: PhD Student
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 I: Intern

In Italic: Have graduated or left during the year

- Peter G.C. Campbell (P) Geochemistry and aquatic ecotoxicology
Séverine Le Faucheur (As)
 Bérénice Bougas (Postdoc)
 Paula Sanchez-Marin (Postdoc)
 Kristin Mueller (PhD)
- Fateh Chebana (P) Statistical hydrology
 Alexandre Lekina (Postdoc)
 Hussein Wazneh (PhD)
- Karem Chokmani (P) Remote sensing and hydrology
 Anas El Alem (PhD)
 Noumonvi Yawu Sena (PhD)
 Yann Dribault (MSc)
 Simon Perreault (MSc)
 Sophie Roberge (MSc)
 Souleymame Konkisre (I)
Magali Wirtensohn (I)
- Patrice Couture (P) Aquatic ecotoxicology
 Michel Amery Defo (PhD)
 Julie Grasset (PhD)
 Audrey Moffett (MSc)
 Sébastien Bélanger-Deschênes (I)
Dean Ferguson (I)
Charlotte Tingaud (I)
- Paul Drevnick (P) Contaminant biogeochemistry
 Benjamin Barst (PhD)
Marie-Josée Parino (I)
- Patrick Drogui (P) Electrotechnologies and water treatment
 Nam Tran (At)
 Rimeh Daghrir (PhD and MSc)
 Mandé Léa Rosine Guitaya (PhD)
 Brahim Seyhi (PhD)
 François Zaviska (PhD)
 Fatou Senghor (MSc)
Raúl Tercero Barrera Contreras (I)
Karima Cheggari (I)
Dorra Ellouze Ladhar (I)
 Asmaa Errachidi (I)
Soumia El Basri (I)
Andréa Lambert (I)
David Quintanaya Loya (I)
Adil Rhazzar (I)
- Sophie Duchesne (P) Urban hydrology and infrastructure
 Nabila Bouzida (At)
 Nomessi Kokutse (Postdoc)
 Babacar Toumbou (Postdoc)
 Thai Nam Pham (PhD)
 Lise Audet (MSc)
 Jihène Zaiem (MSc)
Guillaume Beardsell (I)
 Naoufel Chahid (I)
- Anne-Catherine Favre (P) Statistical hydrology
 Thomas-Charles Fortier-Filion (MSc)
- Claude Fortin (P) Metal biogeochemistry
 Danaé Pitre (At and MSc)
 Bérénice Bougas (Postdoc)
 Zhongzhi Chen (Postdoc)
 Isabelle Lavoie (Postdoc)
- Rachel Olette-Dodson (Postdoc)
 Paula Sanchez-Marin (Postdoc)
 Jonathan Bernier (PhD)
 Anne Crémazy (PhD)
 Michel Lavoie (PhD)
 Simon Leclair (MSc)
 Marc-André Robin (MSc)
Audrey Llevot (I)
- Pierre Francus (P) Limnogeology
 Arnaud De Coninck (At)
 David Fortin (Postdoc)
 Frédéric Bouchard (PhD)
 Nicoleta Ciobanas (PhD)
Stéphanie Cuvén (PhD)
 Guillaume Jouve (PhD)
 Vicky Tremblay (PhD)
 François Lapointe (MSc)
 Gabriel Rodrigue (MSc)
Maxime Boreaux (I)
Manon Turmel (I)
- Bernard Giroux (P) Applied geophysics
 Linda Armelle Nzumotcha Thoumkam (PhD)
 Lorenzo Perozzi (PhD)
 Guillaume Cyr (MSc)
 Benjamin Gosselin-Cliche (MSc)
- Erwan Gloaguen (P) Applied geophysics and geostatistics
 Pierrick Chasseriau (Postdoc)
 Martin Blouin (PhD)
 Camille Dubreuil-Boisclair (PhD)
 Patrick Simard (PhD)
 Christine Bélanger (MSc)
Lorenzo Perozzi (MSc)
Paolo Ruggeri (I)
Corinne Salaün (I)
Mathieu Sauvageau (I)
- Charles Gobeil (P) Aquatic geochemistry
 Sandra Jobidon (T)
 Zouzou Kuzyk (Postdoc)
 Diego Campisi (PhD)
Raoul-Marie Couture (PhD)
Stéphane Feyer (PhD)
 Roger Levasseur (MSc)
 Catherine Boudreau (I)

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In Italics: Have graduated or left during the year

Yves Gratton (P) Physical oceanography
Marie-Emmanuelle Rail (O)
 Claude Belanger (As and *Postdoc*)
 Dominique Boisvert (At)
 Somayeh Nahavandian Esfahani (PhD)
 Caroline Sévigny (PhD)
 Jessy Barrette (MSc)
 Charles Brouard (MSc)

Landis Hare (P) Freshwater ecology and ecotoxicology
 Dominic Ponton (PhD and MSc)
 Isabelle Proulx (PhD)
 Maikel Rosabal Rodriguez (PhD)
 Karine Bertrand (MSc)
 Julien Lacharité (MSc)
Hugo Lavoie (I)

Lyal Harris (P) Structural geology and geophysics
 Vladimir Antonoff (PhD)
 Gregory Dufrechou (PhD)
 Camille Armengaud (MSc)
 Noémie Fayol (I)
Milène Leduc (I)

Pierre Lafrance (P) Organic contaminant biogeochemistry

Isabelle Larocque (P) Paleoclimatology

Isabelle Laurion (P) Aquatic ecology and bio-optics
 Maciej Bartosiewicz (PhD)
 Karita Negandhi (PhD)
 Annabelle Waren (MSc)
Lennie Boutet (I)
 Virginie Sauter (I)

Michel Leclerc (Honorary P) Ecohydraulics
Pierre-Luc Fortin (MSc)

René Lefebvre (P) Hydrogeology
 Xavier Malet (T and I)
 Jean-Marc Ballard (O)
 Cintia Racine (O)
 Harold Vigneault (O)
Belkacem Lahmira (As)
 Marc-André Carrier (At)
 Pierrick Chasseriau (Postdoc)
 Tien Dung Tran Ngoc (Postdoc)
 Marc Laurencelle (PhD and I)
 Daniel Paradis (PhD)
 Laurie Tremblay (PhD)
 Châtelaine Beaudry (MSc and At)
 Patrick Brunet (MSc)
 Emmanuelle Millet (MSc)
Olivier Bouchard (I)
Jean-Bernard Kabran Gnankon (I)
Mathieu Sauvageau (I)

Bernard F. Long (P) Marine sedimentology
 Louis-Frédéric Daigle (T)
 Régis Xhardé (As)
 Mathieu Des Roches (At)
 Stéphane Montreuil (PhD)
 François Aucoin (MSc)
 Valérie Robitaille (MSc)
Constant Pilote (I)
Jean-René Rivard (I)

Tateyama Ryuta (I)
Funakoshi Yoshitaka (I)

Alain Mailhot (P) Urban hydrology
 Samuel Bolduc (At)
 Guillaume Talbot (At)
 Sébastien Raymond (Postdoc)
 Brielly Edouard Arnaud Guede (PhD)
 Vanessa Montpellier (PhD)
 Simon Lachance-Cloutier (MSc)
Ian Beauregard (I)
Thomas Thibault (I)
Christophe Vidil (I)

Michel Malo (P) Structural geology
 Karine Bédard (O)
 Jean-Philibert Moutenet (O)
 Harold Vigneault (O)
 Elena Konstantinovskaya (As)
 Gabriel Huot-Vézina (At)
 Maxime Claprod (Postdoc)
 Franck Diedro (Postdoc)
 Tien Dung Tran Ngoc (Postdoc)
 Gaëlle Grundman (PhD)
 Adeline Parent (PhD)
 Jean-François Grenier (MSc)
 Diego Tovar (MSc)
Guillaume Cyr (I)
Benjamin St-Pierre (I)
 Linda Aubert (Secretary)

Richard Martel (P) Hydrogeology
 Clarisse Deschênes-Rancourt (T)
 Richard Lévesque (T)
 Sébastien Côté (O)
 Luc Trépanier (O)
 Uta Gabriel (As)
Mathieu Laporte-Saumure (As and PhD)
 Vincent Boulianne (At)
 Nicolas Francoeur-Leblond (At)
 Sébastien Lange (Postdoc)
 Genevieve Bordeleau (PhD)
 Adriana Furlan Gumière (PhD)
 Jean-Sébastien Gosselin (PhD)
 Marie-Claude Lapointe (PhD and I)
 Thomas Robert (PhD)
Martin Blouin (MSc)

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In Italics: Have graduated or left during the year

Jean-Philippe Drolet (MSc)
Guillaume Bédard (I)
Rania Bouziri (I)
Jérémy Dostie (I)
 David Fajardo Triana (I)
Louis Jacques (I)
Guillaume Lefrançois (I)
 Herilala Fabrice Randriandelinoro (I)
Véronika Varfaly (I)
 Linda Aubert (Secretary)

Guy Mercier (P) Decontamination and reclamation
 Emmanuelle Cecchi (As)
 Lan Huong Tran (As)
 Pauline Riche (At)
Romain Barbaroux (PhD)
 Sara Bisone (PhD)
 Dileep Palakkeel Veetil (PhD)
 Louis-César Pasquier (PhD and MSc)
 Sanoopkumar Puthiya Veetil (PhD)
 Charles-Edouard Nanci (MSc)
 Guillaume Nielsen (MSc)
 Michel Plourde (MSc)
Vincent Taillard (MSc)
Aymeric Desmoulins (I)
 Assad Mogni (I)
Valérie Potron (I)
 Tengfei Xu (I)

Taha B.M.J. Ouarda (P) Statistical hydrometeorology
 Anik Daigle (As)
Tae Sam Lee (As and Postdoc)
 Christian Charron (At)
Guillaume Dueymes (At)
 Barbara Martel (At)
 Dae Il Jeong (Postdoc)
 Buyngsoo Kim (Postdoc)
 Alexandre Lekina (Postdoc)
Lampouguin Bayentin (PhD)
 Mohamed Aymen Ben Aissia (PhD)
 Martin Durocher (PhD)
Bahaa Khalil (PhD)
 Reza Modarres (PhD)
 Mohamed Ali Ben Alaya (MSc)
Chantal Caouette (MSc)
 Jean-Xavier Giroux (MSc)
 Dorra Hammami (MSc)
 Iris Klein (MSc)
 Bouchra Nasri (MSc)
Catherine Allard (I)
Marjolaine Dubé (I)
Yiping Han (I)
Céline Heuzé (I)
Sylvain Labranche (I)

Claudio Paniconi (P) Hydrogeological modeling
 Cintia Racine (O)
 Mauro Sulis (As and PhD)
 Asma Chemingui (PhD)

Marc Richer-Lafleche (P) Applied geosciences
 Jean-Christophe Aznar (As)
 Hilda Paucar Munoz (PhD and MSc)
 Charlotte Athurion (MSc)
Yves Caron (MSc)
 Mohamed Koita (I)
 Yves Asselin (Field assistant)
 Jean-François Boily (Field assistant)

André Castonguay (Field assistant)
 Édith Chouinard (Field assistant)
 Patrick Lachance (Field assistant)
 Robert Ronald Mamani Mamani (Field assistant)
 Kevin Picard (Field assistant)
 Sylvain Poirier (Field assistant)
 Louis-François Rinfret (Field assistant)

Pierre-Simon Ross (P) Volcanology and economical geology
 Alexandre Bourke (At)
 Julie Anaïs Debreil (PhD)
 Séverine Delpit (PhD)
 Bastien Fresia (MSc and I)
Russel Rogers (MSc)
Julien Avard (I)
Jean-François Desbiens-Lévesque (I)
Olivier Lamarche (I)

Alain N. Rousseau (P) Hydrological modeling
 Alain Royer (T)
 Sébastien Tremblay (T)
 Stéphane Savary (O)
 Sandra Proulx-McInnis (At)
 Sylvio José Gumiere (Postdoc)
 Gwenaél Carrer (PhD)
 Patrick Gagnon (PhD)
Martine Grenier (PhD)
 Grégor Levrel (PhD)
 Muma Mushombe (PhD)
 Philippe Noël (MSc)
 Mathieu Oreiller (MSc)
 Rodrigo Passos (MSc)
Stéphanie Allard (I)
Jessica Boudreault (I)
 François Boulanger (I)
 Justine Carlier (I)
Olivier Fillion (I)
Étienne Foulon (I)
 Daphné Freudiger (I)
 Frédéric Horth Whitton (I)
Kevin Pénard (I)

Yves Secretan (P) Numerical hydrology
 Pascale Matte (PhD)
Mathieu Boudreau (I)

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In Italics: Have graduated or left during the year

André St-Hilaire (P) Environmental and statistical hydrology

Anik Daigle (As)
Bahaa Khalil (As)
Sandra Proulx-McInnis (At and MSc)
Chunping Ou (Postdoc)
Deepti Joshi (PhD)
Julien Mocq (PhD)
Valérie Ouellet (PhD)
Simon Tardif (PhD)
Laurie Beaupré (MSc)
Mohammed Aziz Es Salhi (MSc)
Hélène Higgins (MSc)
Vincent Huot (MSc)

Normand Tassé (P) Geochemistry

Rajeshwar Dayal Tyagi (P) Waste and biomass bioconversion

Éric Lortie (T)
Jyothi Bezawada (As and PhD)
Balasubramanian Sellamuthu (As)
Song Yan (As)
François Chabot (At)
Pappy John Rojan (Postdoc)
Indrani Bhattacharya (PhD)
Jean-Philippe Chenel (PhD)
Mathieu Drouin (PhD)
Jean-Robert Gnepe (PhD)
Amine Mahmoudi (PhD)
Josée-Anne Majeau (PhD)
Jia Miao (PhD)
Tanaji More (PhD)
Ha Pham Thi Thanh (PhD)
Sridhar Pili (PhD)
Neema Prabhakaran Mariyamma (PhD)
Tarek Rouissi (PhD)
Jay Shankar Singh Yadav (PhD)
Xiao Lei Zhang (PhD)
Najib Mhamdi (MSc)
Nabil Bouazzaoui (I)
Zineb El Achhab (I)
Sanae El Harche (I)
Mathieu Gras (I)
Alexandre Hervouet (I)
Azouz Hind (I)

Jean-Pierre Villeneuve (P) Integrated management of water resources

Nomessi Kokutse (Postdoc)
Babacar Toumbou (Postdoc)
Hong Trang Nguyen (PhD)
Phu Duc Nguyen (PhD)
Xuan Tuan Nguyen (PhD)
Thi Thu Ha Pham (PhD)
Louis Blanchet (I)
Audrey Lucchesi Lavoie (I)
Amélie Thériault (I)
Julie Fortin (Secretary)

Other students

PhD students supervised by associate professors

Lauriane Dinis (Martine M. Savard)
Annick Doucet (Martine M. Savard)
Josué Jautzy (Jason Ahad)
Lise Lamarche (Michel Parent)
François Leclerc (Jean H. Bédard)
Jean-François Montreuil (Louise Corriveau)
Maud Naulier (Martine M. Savard)
Jean-François Ravenelle (Benoît Dubé)
Kenneth Williamson (Benoît Dubé)
David Yergeau (Patrick Mercier-Langevin)

Master's students supervised by associate professors

Anthony-Franco De Toni (Louise Corriveau)
Catherine Guay (Miroslav B. Nastev)
Abhidheya Holfeld (Patrick Mercier-Langevin)
Rachel Thériault (Martine M. Savard)

In the Professional Master's Program

Maxime Bélanger
Steve Boivin
Mélissa Châtelain
Raphaël Combes
Jonathan Daigle
Julien Gaubert
Matthew Landry
Charles-Olivier Laporte
Sanae Outoun
Dominic Roussel
Magali Wirtensohn

Other professors

Emeritous

Georges Drapeau
Michel Slivitzky

Honorary

Aïcha Achab
Daniel Cluis
Jean-Pierre Fortin
Sinh Lequoc
Guy Morin
Jean-Louis Sasseville
Alain Soucy
Andre Tessier

Associate

Jason Ahad, GSC-Quebec
Guy Ampleman, DRDC-Valcartier
Jean H. Bédard, GSC-Quebec
Christian Bégin, GSC-Quebec
Sébastien Castonguay, GSC-Quebec
Louise Corriveau, GSC-Quebec
Benoît Dubé, GSC-Quebec
Mathieu J. Duchesne, GSC-Quebec
Michel Houllé, GSC-Quebec
Donna Kirkwood, GSC-Quebec
Denis Lavoie, GSC-Quebec
Patrick Mercier-Langevin, GSC-Quebec
Yves Michaud, GSC-Quebec
Léopold Nadeau, GSC-Quebec
Miroslav B. Nastev, GSC-Quebec

Michel A. Parent, GSC-Quebec
Luc Perreault, Hydro-Québec
Didier Perret, GSC-Quebec
Nicolas Pinet, GSC-Quebec
Christine Rivard, GSC-Quebec
Alfonso Rivera, GSC-Quebec
Martine M. Savard, GSC-Quebec
Sonia Thiboutot, DRDC-Valcartier

Invited

Marc Amyot, Université de Montréal
András Bárdossy, Institut für Wasserbau (Germany)
Simon Barbabé, UQTR
Ridah Ben Cheikh, École nationale d'ingénieurs de Tunis (Tunisia)
Hamel Benmoussa, Centre de recherche industrielle du Québec
Louis Bernatchez, Université Laval
Thomas Buffin-Bélanger, UQAR
Daniel Caissie, Fisheries and Oceans Canada
Bernard Chocat, Institut national des sciences appliquées de Lyon (France)
Paul Cooper, University of Toronto
Daniel Cossa, Institut français de recherche pour l'exploitation de la mer (France)
Simon Charles Courtenay, Fisheries and Oceans Canada
Richard A. Cunjak, Canadian Rivers Institute, University of New-Brunswick
Jean-Pierre Dedieu, LARHRA – CNRS (France)
Salah-Eddine El Adlouni, Université de Moncton
Jaime M. Gárfias Soliz, Centro Interamericano de Recursos del Agua (Mexico)
Pierre-Louis Gosselin, Institut national de la santé publique du Québec
Katy Harlampides, University of New-Brunswick
Eric Johnson, Hartwick College (New York, USA)
Scott Lamoureux, Queen's University
Robie W. Macdonald, Fisheries and Oceans Canada
Jean-Louis Morel, Institut national polytechnique de Lorraine (France)
Mir Abolfazl Mostafavi, Université Laval
Emmanuel Naffrechoux, Université de Savoie (France)
Michel Nolin, Agriculture and Agri-Food Canada
Reinhard Pienitz, Université Laval
Eric Pottier, Institut d'électronique et de télécommunications de Rennes (France)
John F.V. Riva, retired, Université Laval
René Roy, Institut de recherche d'Hydro-Québec
Marie-Odile Simonnot, Institut national polytechnique de Lorraine (France)
Minh Y. Tran, Vietnam Academy of Science and Technology (Vietnam)
Bruno Tremblay, McGill University
Gozo Tsujimoto, Kobe City College of Technology (Japan)
José R. Valéro, retired, Canadian Forest Service
Eric van Bochove, Agriculture and Agri-Food Canada
Kevin J. Wilkinson, Université de Montréal
Fumihiko Yamada, Kumamoto University (Japan)
Fatiha Zidane, Université Hassan II (Morocco)

Other researchers

Associate

Jean Morin, Environment Canada

Invited

Todd E. Arbetter, National Ice Center (USA)
Philippe Archambault, Institut des sciences de la mer de Rimouski
Françoise Behar, Institut français du pétrole (France)
Gilles Bellefleur, Geological Survey of Canada
Claudia Blais, Institut national de la santé publique du Québec
Gerardo Buelna, Centre de recherche industrielle du Québec
Guy Caniaux, Centre national de recherches météorologiques (France)
François Caron, Centre interuniversitaire de recherche sur le saumon de l'Atlantique
Daniel Caya, Ouranos Consortium
Marie Clément, Fisheries and Oceans Canada
Catherine Couillard, Fisheries and Oceans Canada
Bernard Doyon, Collège F.X. Garneau
Peter I. Galbraith, Fisheries and Oceans Canada
Daniel Houle, Ministère des Ressources naturelles et de la Faune du Québec
Feten Jarraya Horriche, Centre de recherches et des technologies des eaux (Tunisia)
Yvon Maranda, Ministère du Développement durable, de l'Environnement et des Parcs du Québec
Stéphane Masson, Parc Aquarium du Québec
Marc Mingelbier, Ministère des Ressources naturelles et de la Faune du Québec
Louis Prieur, Observatoire océanologique de Villefranche-sur-Mer (France)
Milla Rautio, UQAC
Rao Y. Surampalli, United States Environmental Protection Agency (USA)
Muriel Thibaut, Institut français du pétrole (France)
Richard Turcotte, Ministère du Développement durable, de l'Environnement et des Parcs du Québec
Marc Vallée, Fugro Airborne Surveys

Services

In italics: Have left during the year

Direction

Yves Bégin (Director)
Isabelle St-Jacques (Assistant)
Valérie Garant (Secretary)
Ariane Leduc (Secretary)

Research liaison

Carole Parent
Stéphanie Racine
Sophie Walsh-Sauvageau

Administration

Ginette Belleau (Service Head)
Dominique Cantin
Diane Lortie
Marie-Noëlle Ouellet
Mylène Paradis
Manon Poitras
Guylaine Vallée
Evelyne Vallières

Building

Serge Marcoux (Service Head)
Céline Bélanger
Étienne Bérubé
Sylvain Dufour
Gilles Guérin
Sophie Magos
Mario Moisan
Alain Poirier
Louise Robitaille
Luc Rose
Pierre Tailleux

Cartography

Marco Boutin

Computer and telecommunication service

Claude Blanchette (Service Head)
Claude Champagne
Martin Gagné
Luc Jalbert
Patrick Laforte
Marc Saint-Pierre
Sacha Wasylyszyn

Documentation and information

Jean-Daniel Bourgault (Service Head)
Pascale Dion
Sophie Magos
Chantal Paquin
Anne Robitaille
Jean-Michel Thériault

Laboratories

Stéfane Prémont (Service Head)
Anissa Bensadoun
Jean-François Dutil
Sébastien Duval
Mélissa Fallu (Intern)
Pauline Fournier
Philippe Girard
Marc Greendale
Julie Perreault
Lise Rancourt
René Rodrigue
Veronique Tardif (Intern)

Student services

Suzanne Dussault
Johanne Desrosiers

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